VOL. IX, PART IV. *Published* August 1924

The British Mycological Society

(*Recognosce notum, ignotum inspice*)

TRANSACTIONS

Edited by

CARLETON REA and J. RAMSBOTTOM

Price to non-members, Seven Shillings and Sixpence net

CAMBRIDGE UNIVERSITY PRESS
LONDON: FETTER LANE, E.C. 4
ALSO
H. K. LEWIS AND CO., LTD., 136, GOWER STREET, LONDON, W.C. 1
WHELDON AND WESLEY, LTD., 2–4 ARTHUR STREET, NEW OXFORD STREET, LONDON, W.C. 2
CHICAGO: THE UNIVERSITY OF CHICAGO PRESS
(AGENT FOR THE UNITED STATES AND CANADA)
BOMBAY, CALCUTTA, MADRAS: MACMILLAN & CO., LTD.
TOKYO: THE MARUZEN-KABUSHIKI-KAISHA

LIST OF OFFICERS AND COUNCIL FOR 1923

Elected September 1922

President

Professor O. V. DARBISHIRE, Ph.D.

Vice-Presidents

F. T. BROOKS, M.A., F.L.S., W. N. CHEESMAN, J.P., F.L.S.

General Secretary

J. RAMSBOTTOM, O.B.E., M.A., Sec.L.S.
British Museum (Nat. Hist.), Cromwell Road, London, S.W. 7.

Secretary

Miss E. M. WAKEFIELD, M.A., F.L.S.
The Herbarium, Royal Botanic Gardens, Kew, Surrey.

Treasurer and Foray Secretary

A. A. PEARSON, F.L.S.
59, Southwark Street, London, S.E. 1.

Editors

CARLETON REA, B.C.L., M.A.
and
J. RAMSBOTTOM, O.B.E., M.A., F.L.S.

COUNCIL

The OFFICERS, with the following in addition:

Prof. R. H. BIFFEN, Prof. A. H. R. BULLER, E. J. BUTLER, A. D. COTTON, C. H. GRINLING, Prof. DAME HELEN GWYNNE-VAUGHAN, SOMERVILLE HASTINGS, Very Rev. D. PAUL, T. PETCH, Prof. M. C. POTTER, Mrs E. A. REA, Miss A. LORRAIN SMITH, E. W. SWANTON, and H. WAGER.

SUB-COMMITTEE FOR PLANT PATHOLOGY

F. T. BROOKS, M.A. (*Chairman*)
E. J. BUTLER, C.I.E., D.Sc.
A. D. COTTON, F.L.S. (*Secretary*)
T. PETCH, B.A., B.Sc.
G. H. PETHYBRIDGE, B.Sc., Ph.D.
J. RAMSBOTTOM, O.B.E., M.A.

The President and Secretary of the Society *ex Officio*.

A NEW SPECIES OF MONOCHAETIA.

(With Plate VIII.)

By Malcolm Wilson, D.Sc., F.R.S.E., F.L.S.
Reader in Mycology, University of Edinburgh
and
F. C. Ford-Robertson, B.Sc.
Indian Forest Service.

The fungus forming the subject of this note was found on the dead leaves of *Cryptomeria japonica* D. Don, which were still attached to the cast shoots. It was collected in November, 1921, at Raith, Fife, on shoots which had evidently lain on the ground for some months. Detailed investigation of the material was not commenced until January, 1923.

The fructifications, which are isolated and found sparingly on all sides of the leaf, are dull black and smooth, in shape oval to elliptical and up to 1 × ·75 mm. in size when mature. They may project as much as ·3 mm. above the surface of the leaf; young fructifications are more rounded and project to a less degree. On examination the mature fructification appears to consist almost entirely of a spherical mass of dark-coloured spores and is encircled by the ruptured epidermis, an indication that it was in the early stages embedded in the tissue of the leaf. Sections confirm this, and the fructification, seen just below the epidermis, is globose, consisting of a reddish-brown wall about 20 μ in thickness, made up of interwoven hyphae, which on the outer surface gradually pass off into the tissue of the leaf (fig. 1). The inner surface of the wall is sharply delimited by the hyaline sporophores which project from it thickly and bear the elongated spores. As development proceeds the epidermis and wall of the fructification immediately below it rupture and the free edges of both form an aperture which gradually widens to expose the spore-bearing layer. The fructification, immediately after dehiscence, is flask-shaped and, in consequence, the sporophores near the opening are still directed inwards (fig. 2). As the aperture widens this appearance is lost, the spore-bearing layer becoming finally almost flat. Mucilage is evidently produced, even before rupture, by degeneration of the wall and sporophores, and dehiscence is probably brought about by absorption of water and consequent swelling. The mucilage flows out over the surface as a cushion-like layer and carries out the spores embedded in it; by the time that the fructification is widely open the majority of the spores are found on the surface of the leaf in the dark-coloured mass previously referred to.

The spores (fig. 3) are spindle-shaped, constantly five-celled, slightly constricted at the septa, the three central cells (*b*, *c*, *d*) with smooth, chocolate-brown walls of even thickness and pale yellow granular contents; the central cell (*c*) is invariably the darkest. The terminal cells (*a*, *e*) are hyaline, occasionally subhyaline, with scanty colourless contents and often with a single, rather large oil drop. The proximal cell (*a*), which possesses a wall of marked thickness, is separated from the sporophore by a cross wall; the sporophore itself is hyaline, 4–20 μ long, 1–2 μ thick and is often divided into two or three cells. The distal cell (*e*) is hyaline, thin-walled, with scanty contents, occasionally with an oil drop and is prolonged into a tapering seta which is generally bent or curved, 20–32 μ long and barely 1 μ thick at the base. The process of spore development has not been elucidated but the structures shown at *f* and *g* in fig. 3 appear to be early stages.

The mycelium in the leaf consists of very delicate hyaline hyphae which spread in all directions through the tissues. At maturity the fructifications appear very shrunken and are not easily distinguished in the dead leaf. Although at the time of examination the material had been kept for fourteen months in a dry condition in the laboratory, the spores released from the soaked material were found in a germinating condition. Germination, which may take place within twenty-four hours, is invariably preceded by a change in colour and cell contents. The brown cells, which alone produce germ tubes, become paler in colour and conspicuous oil drops appear in the contents, although they are rarely or never seen in the resting spore.

On germination the outer layer of the wall is ruptured and the inner colourless layer emerges to form a germ tube of variable thickness usually about 2 μ in diameter (fig. 4). Near the point of emergence the protoplasm becomes paler in colour and in the germ tube is completely hyaline; the oil drops generally flow out as development proceeds. Whilst still very short the germ tube may bifurcate before any cross septa are formed (*a*, fig. 4).

In most cases germ tubes are only produced from the dark-coloured cells adjoining the central one, each of which may produce two. Most frequently two germ tubes are produced from the whole spore, each of the cells contributing; the maximum number, four, is rarely found but three is fairly common. The central cell has only once been seen to germinate and the terminal hyaline cells apparently never do so. During germination the setae gradually disintegrate. Germination was obtained as readily in a 2 per cent. solution of glucose as in water.

Spores placed on agar media readily produce an abundant mycelium. Different media were employed and gave growths of

varying vigour. Luxuriant cultures were obtained on media prepared with extracts of prune, Scots pine, and potato and on the standard lemco-peptone medium. Media made with extracts of Douglas fir and ash only produced thin limited growths, consisting of delicate interwoven hyphae. Cultures made on bread soaked in the various extracts produced luxuriant cultures which never bore fructifications.

The mycelium is at first white but within a week assumes a coral-pink colour. The hyphae (fig. 5) are of variable thickness from 1·5–3·5 μ, hyaline in the earlier stages of growth, with granular protoplasm and no obvious inclusions or vacuoles. Cross septa are numerous and the hyphae are freely branched; in many cases a septum is not present at the point of insertion of a branch. The septa are commonly found at about a distance of 8 μ apart but the elongating terminal cell may attain a length of 30 μ.

The assumption of the coral-pink colour is associated with two changes in the mycelium: (1) the development of stout thick-walled hyphae which contain aggregations of pink material in the cells (fig. 5, *a*) and (2) the appearance of strands of medium-sized hyphae with a parallel arrangement which take on a pink colour as a whole (fig. 5, *b*). The connection, if any, between these two phenomena, has not been determined.

Fructifications usually appear on the cultures after about ten days. The first indication of their development is the appearance of a minute dark mass slightly below the upper surface of the mycelium. A fructification always appears at the point of infection of the medium and is generally accompanied by a number of others scattered irregularly over the culture. The central fructification being usually the first to mature is, on dehiscence, a conspicuous feature (fig. 7). Development is very rapid and shortly after the dark masses have appeared a black shining drop is seen on the surface above each fructification indicating that dehiscence has commenced. This drop consists of a mass of extruded mucilage containing spores. The addition, or even the close proximity, of water causes a rapid change; the spores flow apart with great rapidity and only remain loosely held by the diffuse mass of thin mucilage. This will likewise occur, after a time, in an untouched culture. The fructifications produced on culture media agree generally in structure with those found on the leaves (fig. 6); the spores, however, are larger measuring 25–32 × 8–10 μ with stalks 8–25 μ long and seta 10–50 μ.

The extruded spores, if undisturbed, soon germinate. About three weeks after inoculation of the culture a bright pink tuft of mycelium is produced apically on the spore mass from the

germinating spores. This tuft extends to the base of the mass but does not spread to any extent over the surrounding mycelium.

The fungus under consideration clearly belongs to the genus *Monochaetia*, which is distinguished from *Pestalozzia* (of which it previously formed a part) by the presence of a single seta. A considerable number of species have been described in the former genus but few of these occur on conifers and we have been unable to find any of which the description agrees with the present fungus. In consequence we propose to make this a new species under the name *Monochaetia Cryptomeriae*. There is no evidence to show that the species is parasitic, the fructifications only being found on the dead leaves lying on the ground.

MONOCHAETIA CRYPTOMERIAE, n. sp.

Acervulis amphigenis, circularibus vel ovoideis, sparsis, subnigris, opacis haud nitentibus, laevibus, innato-erumpentibus, ·75–1 mm. diam.; sporulis fusiformibus, utrinque acutiusculis, 4-septatis, vix constrictis, 22–30 × 7·5–10 μ, brunneis, loculis terminalibus hyalinis, apice setula, 20–32 × 1 μ, hyalina, filiformi, curva dein rectiuscula terminatis; sporophoris filiformibus, hyalinis, 4–20 × 1–2 μ.

Hab. in Scotia, Raith, Fife, in foliis dejectis *Cryptomeriae japonicae*.

DESCRIPTION OF PLATE VIII.

Figs 1, 2, 6 and 7 are from photographs; figs 3, 4 and 5 are from camera lucida drawings.

Fig. 1. Transverse section of the leaf of *Cryptomeria japonica* showing the young fructification. × 190.

Fig. 2. Similar section of a mature fructification. × 190.

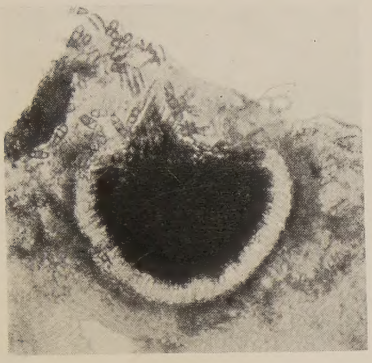
Fig. 3. Spores in different stages of development: *a*, proximal, *e*, distal terminal cells; *b*, *c*, *d*, central cells; *f*, *g*, are probably early stages of development. × 610.

Fig. 4. Spores germinating in water; at *a*, the germ-tube is bifurcating. × 610.

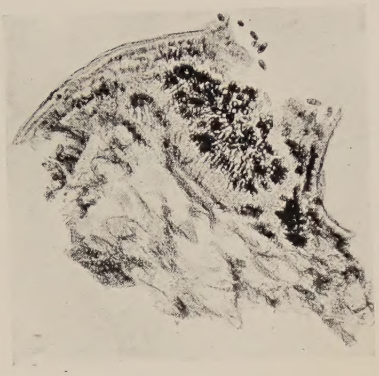
Fig. 5. Mycelium from culture: *a*, stout hyphae containing aggregations of pink material; *b*, strands of hyphae. × 610.

Fig. 6. Section of fructification from culture. × 190.

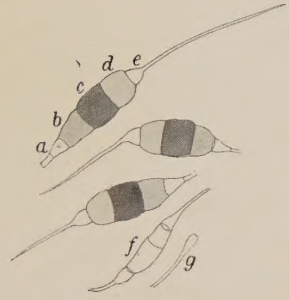
Fig. 7. Central portion of a culture showing fructifications which have extruded their spores in masses of mucilage (natural size).



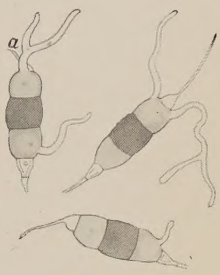
1



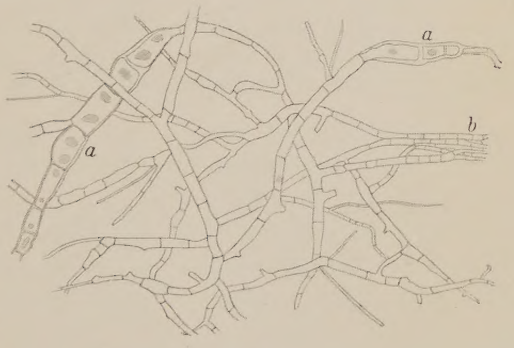
2



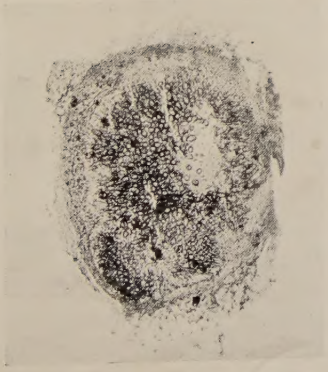
3



4



5



6

7

THE DEVELOPMENT OF GALLACEA SCLERODERMA (CKE.) LLOYD.

(With Plates IX and X.)

By G. H. Cunningham,
Government Mycologist, Department of Agriculture, Wellington, N.Z.

The monotypic genus *Gallacea* was proposed by Lloyd (*Lyc. Aust.* p. 37 (1905)) as the result of an examination of the type specimen of *Mesophellia Scleroderma* Cooke, which he considered, on account of the difference in the nature and structure of the gleba, could not be classed in the genus *Mesophellia*. He placed his new genus in the Lycoperdaceae (section anomalae).

Recently the writer forwarded specimens of what he believed to be this species to Mr Lloyd who in reply sent a copy of two articles published later in *Mycological Notes*, VII, p. 1201 (1923). Here he changed the name to *Gallacea violacea* (Cke. et Mass.) as he found that Cooke and Massee had subsequently described the same species as *Rhizopogon violaceus*. He also commented on the position the genus should occupy, suggesting that it and several other genera (*Diploderma, Hysterangium, Mesophellia, Rhizopogon* (in part), *Jaczewskia, Phallogaster* and *Protubera*) on account of the agreement of certain characters, notably spore characters, should be placed in a distinct group or family.

As the fungus is fairly abundant in a certain locality near Wellington, the writer decided to work out the development, with a view to obtaining some light upon its phylogenetic position.

A detailed description of the mature plant is given, as the fresh specimens do not altogether agree with Lloyd's descriptions.

GALLACEA SCLERODERMA (Cooke) Lloyd, *Lyc. Aus.* p. 38 (1905).
Mesophellia Scleroderma Cke., *Grevillea*, XIV, p. 11 (1885).
Rhizopogon violaceus Cke. et Mass., *Grevillea*, XXI, p. 21 (1893).
Gallacea violacea (Cke. et Mass.) Lloyd, *Myc. Notes*, VII, p. 1201 (1923).

Peridium violet, depressed-globose, often irregularly lobed, up to 10 cm. broad, and 6 cm. high, minutely tomentose, almost smooth, dull, dry, thick, 2–3 mm.; with several coarse, violet-tinted rhizoids springing from the base; drying dull brown, with traces of violet in depressions on the surface, becoming minutely rugulose.

Gleba olivaceous or dark chestnut-brown, traversed by numerous gelatinous, hyaline trabeculae which spring from a

sterile basal disc, cells polygonal or elliptical, minute, 0·25–1 mm. diam.; in old or dried specimens becoming hollow in the centre, the gleba collapsing and lining the inner walls of the peridium and trabeculae, bay brown. Capillitium absent. Spores smooth, elliptical, frequently pedicellate, tinted yellow or olive, almost hyaline, 6–11 × 3·5–5 μ.

Habitat: Gregarious or caespitose on the floor of beech forest.

Distribution: New Zealand.

Locality unknown, T. Kirk. Specimen in Herb. Kew.

Locality unknown, Reader. Specimen in Herb. Kew.

Beech Forest, York Bay, Wellington, 80–100 m., E. H. A. Atkinson! E. J. Butler! G. H. C. Dun Mt, Nelson, 650 m., J. C. Neill! Queenstown, Otago, 450 m., W. D. Reid!

The plants are at first subterranean, but as they approach maturity they appear on the surface. They occur commonly in groups of half-a-dozen or more and are rendered conspicuous by the violet colour of the peridium.

Some twelve stages were obtained and these were found sufficient to give a connected idea of development. The material was fixed in picro-formol, sectioned and stained in iron-alum haematoxylin followed by a 1 per cent. solution of iodine green in clove oil. This combination gave satisfactory results as both nuclei and hyphae are readily stained by it.

Structure of the Mature Plant.

The plant is sessile, being attached to the substratum by a few basal rhizoids. It consists of a thick, coloured cortex—the peridium—enclosing a cellular gleba. No columella is present, though there is a sterile basal disc, from which several trabeculae arise.

Peridium. This consists of a single thick layer (2–3 mm.), (fig. 8), coloured externally, dingy-white internally. It is composed of closely woven, much branched hyphae, in which numerous clamp-connections are present. The hyphae remain distinct during the life of the plant, and at no time are gelatinised, nor do they assume the form of a pseudoparenchyma. The colour is due to the presence, in the outer layers of hyphae, of numerous pigment granules which are embedded in the protoplasm lining the walls of the hyphae. Such granules become conspicuous in sections on account of the readiness with which they take the haematoxylin stain. The peridium is attached throughout to the plates of the gleba, and is not separable from them.

Gleba. In fresh plants the gleba is minutely cellular. It consists of very numerous tramal plates enclosing polygonal or irregularly elliptical lacunae. The whole gleba is traversed by

several trabeculae which arise from a basal disc, and ramify in a radial direction from it. At the base the trabeculae are stout and conspicuous, but as they approach the periphery they become smaller, until finally they are barely discernible from the tramal plates (fig. 13). They give off branches throughout their length; these merge with the tramal plates and probably serve to add rigidity to the plant. The majority of the tramal plates arise from the trabeculae.

A tramal plate consists of three parts: (*a*) an inner layer, the trama, formed of hyphae arranged in a parallel manner, with their long axes parallel with the long axis of the plate; (*b*) a layer on either side of this, the subhymenium (fig. 6), composed of several layers of subglobose or polygonal cells, somewhat greater in diameter than the tramal hyphae; these bear on their proximal surfaces, basidia arranged in palisade fashion collectively forming (*c*) the hymenium (fig. 6). The basidia are somewhat inflated, and each bears, on short sterigmata, six minute, continuous spores. No cystidia or other aberrant cells are present.

Development.

General. The young plant is discernible first as a small swelling on the dorsal surface of the rhizoid, close to another and usually larger developing plant. It increases in size until it becomes somewhat pyriform, being at this stage about 1 × 0·5 mm. Sometimes two or even more may be found growing closely compacted together. In such a case it is not uncommon to find them fused at a later stage. In fact the lobed appearance of many mature plants is due to this fusion, as their structure shows.

Sections of the primordium of the peridium show that it first consists of undifferentiated, closely woven hyphae. This becomes less compacted, and in specimens of 1·5 × 1 mm. a zone of small cavities appears, surrounding a dense central mass of hyphae (fig. 9). This zone is somewhat dome-shaped and the cavities are few and ill-defined. For some time after, or until the plant is about 7 × 5 mm. these cavities enlarge slightly but do not appear to increase in number to any extent. Plants this size begin to approach the surface, colour appearing in the peridium as it becomes exposed. When they are clear of the surrounding soil, the plants commence to increase somewhat rapidly in size, and soon reach maturity.

Development of the peridium. Mention has been made of the first appearance of a dome-shaped zone of irregular cavities in the primordium of the gleba. This zone marks off a peripheral mass of hyphae, the primordium of the peridium. At first it is

thick and composed of somewhat loosely intertwined, much branched hyphae (fig. 9). As the plant increases in diameter the cortex becomes slightly thinner, owing to the hyphae of which it is composed becoming more closely compacted; otherwise little change occurs until the plant appears on the surface. As portions become exposed to the light, colour appears in them, due to the formation of the pigment granules already mentioned. Little change then takes place until the plant is about half-grown, but from this stage until maturity practically all increase in diameter is due to growth of the inner portion of the peridium, with the formation of tramal plates.

Development of the gleba and trabeculae. The dome-shaped zone of cavities encloses a column of densely woven, undifferentiated hyphae, which gives rise to the trabeculae and sterile basal disc (fig. 9). The cavities of this zone are at first few in number and are large and irregular in size and shape. They are separated from one another by thin plates formed of closely compacted, parallel hyphae. Scattered papillae, often arranged in small ridges, arise on these plates, and on these, solitary scattered basidia appear, bearing from one to four spores (figs. 1–3). No definite hymenium is present, nor does it appear until the plant has reached a much later stage of development. The cavities slowly increase in number and size as the plant increases in diameter, and basidia become more numerous, although as yet still confined to scattered papillae. These large and irregular cavities continue to appear until the plant has reached the surface of the ground, the plant at this stage being about 7×5 mm. The greater part of the gleba is seen to be occupied by them, save for the central column of sterile tissue. When the plant reaches the surface, a second phase of development commences. Up to this time growth has been slow, and internal differentiation but little advanced. Now, however, considerable growth occurs in the trabeculae and tramal plates; they increase considerably in thickness, and numerous branches are given off from them. These divide the large cavities into smaller ones (fig. 11), and at the same time lacunae appear in the plates and smaller trabeculae, so that in a short space of time the whole zone, formerly occupied by a few large cavities, is broken up into very numerous smaller ones (fig. 12). As these lacunae appear their walls are lined with a definite hymenium, the basidia bearing six spores, the normal number of the mature plant. Growth of tramal plates and trabeculae continues in this manner for some time until the whole of the gleba, with the exception of those portions occupied by trabeculae and sterile base, consists of minute lacunae and their accompanying hymenium.

Lacunae invariably arise by certain cells within a small area in the hyphae of the tramal plates or smaller trabeculae becoming multiseptate, but not increasing in length. These smaller cells become somewhat inflated and globose. They are then torn apart along a median zone, so that a small cavity is formed (fig. 4). This is at first lined by the inflated cells which shortly give rise to basidia, the lacuna at the same time becoming more or less elliptical.

At a slightly later stage a third phase of glebal formation is entered upon. Lacunae appear to be rapidly formed in the region of the inner wall of the peridium, their formation proceeding much more slowly in the major part of the gleba. The hyphae of the inner wall of the peridium grow rapidly, and lacunae appear in it (fig. 13) as tissue is added to this peripheral region.

The trabeculae and basal disc have now become considerably reduced in thickness, the basal disc being confined to a small pulvinate region at the base (fig. 13); the trabeculae, although fairly stout at their junction with the disc, become thinner as they approach the peridium, until they are barely discernible where they merge with it.

When the plant is about half size (or even earlier) the tramal hyphae and trabeculae become gelatinised, further increase in size being confined to the inner layer of the peridium, the hyphae in this region continuing to grow, giving rise to glebal tissue until maturity is reached. In the mature plant the whole of the tramal plates and trabeculae, with the exception of the hymenium and subhymenium, are gelatinised, but the peridium remains unaffected throughout the life of the plant. Structurally there is no difference between tramae and trabeculae, save that of size, for the tramae arise from the trabeculae and both give rise to hymenium. Nevertheless, for facility of description it is necessary to retain these distinctive names.

Mature or dry plants are quite hollow, the collapsed gleba being distributed as a thin film over the inner walls of the peridium and trabeculae; the latter being stouter than the tramae are able to retain their form, giving the plant a veined appearance when cut (fig. 8). That shrinkage is due to the drying of the gelatinous portions of the tramal plates (tramae) is obvious when the following facts are considered: if half-grown plants are sectioned, they are seen to be solid throughout, yet if they are dried, and again examined, collapse of the gleba will be seen to have taken place, showing that loss of moisture is the determining factor; should sections of this dry gleba be placed in water, they slowly swell until they assume their normal size. Furthermore, should plants collected before gelatinisation of

the tramae has occurred, be dried, collapse of the gleba does not occur. The gleba is olivaceous when the plants are fresh, but in old dried specimens it is a dull bay-brown, and is very brittle to the touch.

Cytology.

The hyphae of the cortex and gleba are invariably bi-nucleate. The basidia are at first slightly inflated; in mature plants they measure about $100 \times 30\mu$. A fusion nucleus is formed in the usual manner and this divides until six nuclei are formed. These migrate to the spores, and there divide, so that each spore is binucleate. The spores are borne on short and slender sterigmata. Clamp-connections are abundant in the tissues of the cortex, tramae and trabeculae.

Systematic Position of the Genus.

The development of the gleba and cortex in their earlier stages is similar to that of *Hysterangium*, which Fischer (1900) places in the Hysterangiaceae. The single peridium, sterile basal disc, trabeculae and phalloid-like spores are also characteristic of this genus. The peculiar manner in which the gleba collapses in adult plants (a character not confined to this genus, however, for the writer has in his possession specimens of a species of *Gautieria* which also possess it) and especially the six-spored basidia are characters which separate it from *Hysterangium*.

Lloyd has already noted the similarity of spores of this and several other genera, and suggests that they should be placed in a separate family. Unfortunately the genera mentioned by him have in many cases little in common, differing in such major particulars as the presence or absence of capillitium, permanent gleba, and number of spores on the basidium.

It must be admitted that the present systems of classification of the Gasteromycetes are unsatisfactory, as many genera with little in common are regularly placed in the one family. Recognising this unsatisfactory condition, the writer has for some time past been engaged on a reclassification of the Gasteromycetes, the publication of which is delayed pending the investigation of the development in several other New Zealand genera. Meanwhile he believes that *Gallacea* should be placed in the Hysterangiaceae of Fischer, for it agrees more closely with *Hysterangium* than with any other genus. This grouping is merely tentative, for in his forthcoming paper the writer intends to place this and several other genera in a distinct family.

Thanks are due to Mr J. C. Neill, of this laboratory, for the preparation of the sections used in the preparation of this paper, and to Mr Neill, Mr E. H. Atkinson and Mr W. D. Reid, also of this laboratory, for contributions of specimens.

SUMMARY.

1. The monotypic genus *Gallacea* is confined to New Zealand.

2. Development proceeds by four stages: (*a*) the primordium consists of closely woven, intricately branched hyphae; (*b*) a dome-shaped zone of cavities appears, surrounding a central undifferentiated area, and surrounded by the primordium of the peridium, these cavities are large, and do not possess a definite hymenium, basidia appearing on small scattered papillae; (*c*) rapid growth of tramae and trabeculae, with appearance of numerous lacunae lined with hymenium; (*d*) gelatinisation of tramae and trabeculae, accompanied by peripheral formation of gleba around the inner margin of the peridium.

3. Basidia are at first 1–4-spored and are borne on irregular scattered papillae, but after the appearance of a definite hymenium (*c*) they become regularly six-spored.

4. Colour appears in the outer layers of hyphae of the peridium as soon as the plant appears on the surface. It is due to the presence of pigment granules in the protoplasm lining the cell walls.

5. At maturity the gleba collapses, owing to loss of moisture from the tramae and smaller trabeculae, and lines the inner walls of the peridium and the trabeculae which persist.

6. Spores are invariably binucleate.

7. The genus resembles closely the genus *Hysterangium*, and on that account is tentatively placed in the Hysterangiaceae.

LITERATURE CITED.

FISCHER, ED. Hymenogastrineae in Engler and Prantl. Natürlichen Pflanzenfamilien, II, pp. 296–313, 1900.

LLOYD, C. G. The Lycoperdaceae of Australia, New Zealand and Neighbouring Islands, pp. 1–44. Cincinnati, 1905.

EXPLANATION OF PLATES IX AND X.

All drawings and photographs are original. The drawings have been made with the aid of a camera lucida.

Figs. 1–2. Spores borne on papillae scattered over the trabeculae.

Fig. 3. Later stage in which scattered basidia have appeared.

Fig. 4. Formation of a lacuna by fissuring of the trama; *lac.* lacuna; immature hymenium on the left, undifferentiated tramal tissue on the right.

Fig. 5. First formed hymenium. Note the long and slender basidia, which as yet bear only four spores.

Fig. 6. Mature hymenium, with a basidium bearing six spores. *Hym.* hymenium; *sub.* subhymenium; *tr.* trama, gelatinised in section on the right.

Figs. 1–6 × 1400.

Fig. 7. Photograph of mature and immature plants, the latter in side view. × ½.

Fig. 8. Photograph of the same plants sectioned. Note the thick peridium and collapsed gleba of the mature plant. The veined appearance is due to the persistence of the larger trabeculae. × ½.

Fig. 9. Photomicrograph of young plant shortly after the commencement of differentiation of the gleba. Note the dome-shaped zone of large cavities surrounding the central columella. × 25.

Fig. 10. Stage showing the development of trabeculae. Spores are present on many of these, borne on scattered basidia. A well-defined sterile base is present. × 20.

Fig. 11. Slightly later stage, showing commencement of secondary growth in thickness of the trabeculae. Note that the columella has almost disappeared. × 12.

Fig. 12. Not quite median section through the stage in which secondary growth of the trabeculae is well advanced. Hymenium is now present, fig. 5 being a drawing from this section. × 10.

Fig. 13. Section through a plant shortly after commencement of the third or peripheral stage of growth. The trabeculae are already gelatinised, the peridium well defined and the hymenium at the stage shown in fig. 6. The larger trabeculae persist as the veins shown in fig. 8, left. × 6

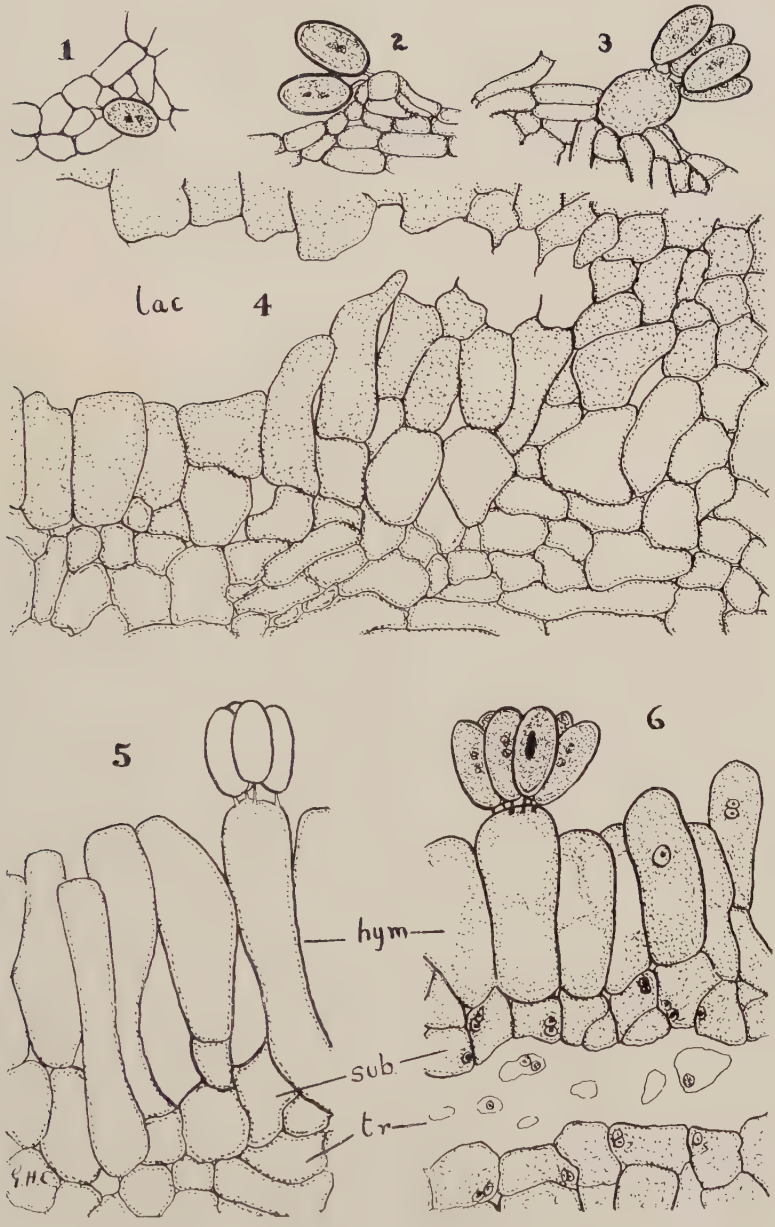
STRAINS OF RHIZOCTONIA SOLANI KÜHN (CORTICIUM VAGUM BERK. AND CURT.).

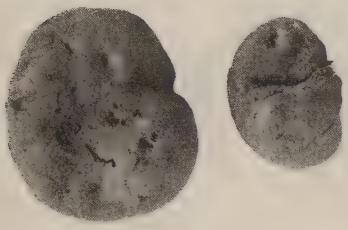
By H. R. Briton-Jones, B.Sc., D.I.C., A.R.C.S.,
University of Bristol Agricultural and Horticultural Research Station, Long Ashton.

Introduction.

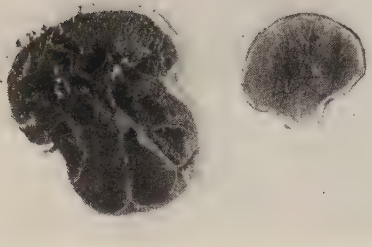
During the course of work in Egypt in connection with the "Sore-Shin" disease of cotton seedlings caused by *Rhizoctonia Solani* Kühn, the fungus was induced under experimental conditions to produce its fertile stage *Corticium vagum* Berk. & Curt. On comparing the *R. Solani* from cotton in Egypt with isolations of the same species from other countries it was observed that there were considerable differences between them in culture. Duggar (1) had previously noted such differences and stated that "in general it is felt that these differences are such as might be due to permanent differences in the pathological strains, on the one hand, or may be regarded as temporary differences due to recent environment on the other." In order to ascertain whether such differences are temporary or permanent it was necessary to grow different forms simultaneously under exactly the same conditions of moisture, temperature, aeration, light, nutrition, etc., and further to compare their behaviour as parasites on the same hosts under the same conditions. By the kind permission of Professor Barker, the writer was able to do this on joining the staff of the above station.

Work was commenced with five forms. *E* isolated from cotton (Egypt); *S* and *A* from diseased potato in England (H. S. Stirrup and Mrs N. L. Alcock); *I* from India (F. J. T. Shaw) and *B* from the Missouri Botanic Garden, U.S.A. Later *PO* and *W* from Potato and *PE* from Garden Pea, England (W. Buddin) was added.

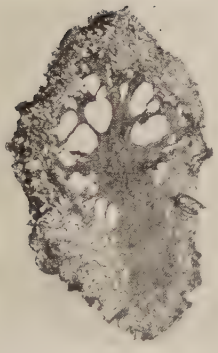

1
2
3
lac
4
5
hym
sub
tr
6



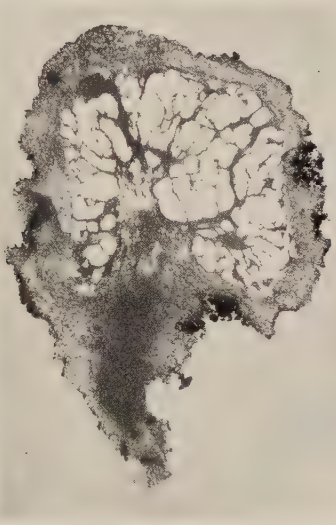
7



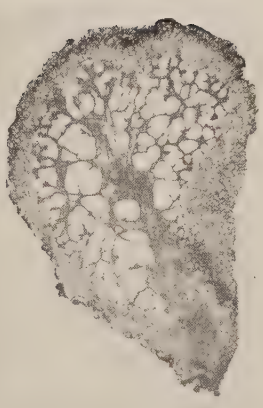
8



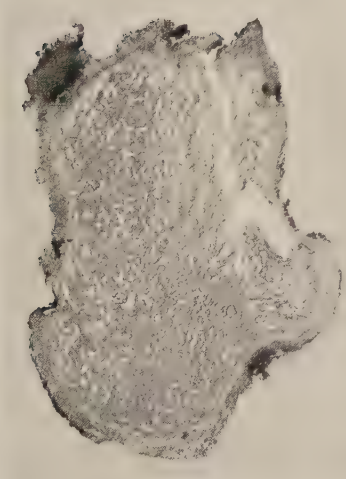
9



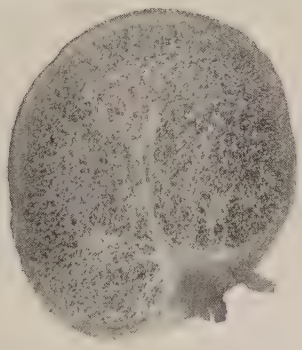
10



11



12



13

Media. The above forms of *Rhizoctonia Solani* have been grown for several months, and in some cases for over two years on different kinds of liquid and solid media including the following: steamed potato, steamed turnip, steamed carrot, prune agar, potato agar, malt extract agar, boiled rice, malt extract gelatin, milk, carrot extract, turnip broth, bouillon, apple extract, Naegeli's solution, Ufchinsky's solution, and malt extract.

All forms grew well on all the solid media but growth was feeble and slow on most of the liquid media, particularly bouillon, apple extract, Naegeli's solution, and Ufchinsky's solution. Of the liquid media the best growth was obtained on milk and turnip broth. None of the fungi grew well on any medium which was unsuitable to the others, and the best medium for all was steamed potato.

Macroscopic Characters.

When grown on the above media it was observed that in some cases there was considerable variation in the colour, amount of aerial growth and the size and number of the sclerotia, within the one form. In spite of this, however, it was possible from certain characteristics of growth to distinguish some of the forms from others, and these diagnostic features were retained throughout. The two extreme cases were *I* and *B*, since the former produced sclerotia which were darker, more discrete, and more even in size than any of the other forms; the latter, on the other hand, did not produce a single sclerotium on any medium. Like the other sclerotia-producing forms, *I* produced larger and a greater number of sclerotia on media like steamed potato, carrot and turnip than on agar and gelatin compounds. Previous experiments with *E* have shown that this is due to the fact that the former media retain moisture for a longer period and allow of better aeration within the medium itself than is the case with agar and gelatin. For these reasons the fungi are able to continue growth for a much longer period. The growth of the mycelium is confined to the surface layer on agar and gelatin and does not penetrate deeply into the medium owing to the absence of oxygen. This is probably also the reason why the fungi do not grow so well on liquid media. All the sclerotial forms produced larger sclerotia on fresh agar medium than on the same medium which had become slightly dry. If the dried agar medium is melted, cooled, and a subculture made immediately afterwards, sclerotia are formed which are of the same size as those produced on freshly made medium. This is due to the fact that moisture in the form of drops of water on the sides of the tubes or Petri dishes is favourable to their rapid and continued growth. This sensitiveness to the presence of

Fungus	Medium	Colour of mycelium	Aerial growth	Size and shape of sclerotia	Colour of sclerotia	Remarks
E	P	Buff-brown	Strands of brown hyphae connected with sclerotia formed on sides of tube	Somewhat flat when formed on surface of medium. Roundish on sides of tubes 2–11 mm. in diam. Often coalesce	Whitish-buff-dark brown, depending on age. Often slaty-grey on outside	The larger flat sclerotia on medium often possess characteristic slaty-grey colour which distinguishes *E* from *S*, *PO* and *PE*. Mycelium forms buff-coloured felt resembling that of *B*
E	M	Buff	do.	Roundish, 1–2 mm. in diam.	Whitish-buff-brown	Forms buff-coloured felt as in (1)
I	P	Buff to brown	More aerial growth than *E*	Roundish, 1–5 mm. in diam.	Whitish-buff and mostly dark velvety brown	Sclerotia more discrete and rounder than in other forms. Hyphae connected with sclerotia not easily seen with naked eye. Forms more sclerotia on sides of tubes than other forms
	M	do.	do.	Mostly 2–3 mm. in diam.	do.	—
S	P	Buff-brown	As for *E*	As for *E*, but more woolly	Browner than *E* and slaty-grey colour absent	—
	M	do.	do.	do.	As for *E*	This is intermediate between *E* and *I*. Sclerotia flatter than *I* and darker and larger than *E*

A	P	Mostly deep brown	Copious, thick, woolly, dark brown growth above medium	Difficult to measure owing to coalescing and very woolly nature	Reddish brown	This resembles *W* more than the others but is a much darker brown in colour. Growth same in all media
	M	do.	do.	do.	do.	do.
B	P	Light buff never brown	None at any time	No sclerotia	—	The growth of this fungus is the same on all media. Forms thick light buff felt of mycelium on surface of medium
	M	do.	do.	do.	—	—
PO	P	As for *S*	As for *S*	As for *S*	As for *S*	No marked differences between *S*, *PO* and *PE*. All resemble *E* except for minor differences given above
PO	M	do.	do.	do.	do.	
PE	P	do.	do.	do.	do.	
PE	M	do.	do.	do.	do.	
W	P	White-buff	Copious thick woolly buff-coloured aerial growth	As for *A*	Buff on outside and brown on inside	Very like *A* except for colour. Growth same on all media
W	M	do.	do.	do.	do.	—

oxygen and moisture is also shown in the field by the fact that the fungi attack their hosts preferably at the ground level where both factors are most suitably balanced. The foregoing table gives the macroscopic characters of the forms when grown on the freshly made media which proved to be most suitable for growth and diagnostic characters*. The descriptions refer to cultures about one month old. All with the exception of *B* produce in the first week a fair amount of aerial growth which collapses when the medium begins to lose its moisture. The column "Aerial growth" in the table refers to that which is present when the culture is one month old or more.

From the above it will be seen that *I*, *A*, *B*, and *W*, can be easily distinguished by their mode of growth, and with practice *E* can also be distinguished from all others by a characteristic slaty-grey colour of the surface of the sclerotia on potato. On agar the latter can be distinguished by the large number of small sclerotia (about 1 mm. in diam.) formed on sides of tubes and by the fact that the mycelium covers the surface of both media with a felt of growth resembling that of *B*.

Temperature and Rate of Growth. A comparison between the rates of growth were made by measurements and observations on several cultures on different media at temperatures of 0–1° C., 5–8° C., 21–23° C. The manner of subculturing, although done as uniformly as possible, did not always give the same results. In a number of subcultures of any one form some commenced growth quicker than others and any slight difference in the moisture content of the medium or air in the tube or Petri dish made an appreciable difference in the rate of growth. For comparing the rate of growth at the above temperatures subcultures of all forms were made at the same time from young rapidly growing cultures of the same age incubated at 21–23° C. and immediately placed in chambers and kept there for five days. At temperatures 0–1° C. none of the fungi made any growth whatsoever. At 5–8° C., *E*, *I* and *B* made no growth. The disc of growth of *W* measured 5 mm. in diameter and for *S*, *A*, *PO* and *PE* growth ranged from 20–22 mm. in diameter. On placing the cultures kept for five days at the lower temperatures in an oven at 21–23° C., growth took place within twenty-four hours and continued as usual. At 21–23° C. the fungi can

* These were steamed potato and malt extract agar prepared as follows: *Steamed potato* (*P*) potato cut into wedge-shaped pieces, placed on moistened cotton-wool at the bottom of large tubes and sterilised by steaming. *Malt extract agar* (*M*), 200 grs. crushed barley to 1000 c.c. of distilled water at 45° C. Kept at 45° C. for half an hour, then temperature raised to 70° C. in half an hour. Kept at 70° C. for one hour and filtered. Distilled water added to S.G. 1·020. Then 3 per cent. of agar added, autoclaved, cooled and egg albumen added. Autoclaved, filtered, tubed and finally autoclaved.

be divided into three groups. The most rapid growers were *E, PO, PE, S* and *I*; the slowest were *A* and *B*. The fungus *W* took an intermediate position between the above two groups. At this temperature and normal room temperatures *I* consistently formed sclerotia quicker than the others. The observations were made with cultures from mycelia which had been isolated from a common host (cress seedlings).

Effect of Light. A series of cultures of all the forms was made in Petri dishes and placed under a blackened sheet of tin so that only one half was exposed to the light. None of the forms showed any reaction to light.

Pathogenicity.

The following experiments were carried out with a view to ascertaining whether there was any difference in the parasitism of the forms on the same host under the same conditions.

Experiment I. The fungi used in this experiment were *E, I, S, A* and *B* on broad bean and garden pea. The experiment comprised ten lots of five flowerpots (3 in. diam.) which were filled with sand and treated as follows:

1. Three seeds of broad bean sown in each of the five pots. A piece of potato on which the fungus was growing was placed in contact with the seed in three of the pots. Seed and fungus were then covered with sand and watered with tap water. In the other two pots no fungus was placed with the seed (controls).

2. As for 1, but three seeds of garden pea sown in place of broad bean.

3 and 4, 5 and 6, 7 and 8, 9 and 10 were similar to 1 and 2, but fungi *I, S, A* and *B* respectively were used.

All were treated on March 26th and placed together in a greenhouse. The week following the date of sowing was bright and sunny with the result that no marked difference could be seen between the controls and infected in any series. It should be pointed out that the soil temperature was not sufficiently high to inhibit the growth of the fungi, but acted indirectly by hastening the growth of the seedlings and increasing the rate of evaporation from the pots.

Experiment II. This was a repetition of Experiment I, except that six-inch pots and distilled water were used instead of three-inch pots and tap water. The date of sowing was April 11th; the plants were examined on May 14th. As in Experiment I no difference was observed between the controls and infected in the pots containing garden peas. The results for the broad beans series were as follows:

Seedlings infected with fungus *E* gave (1) two healthy, one diseased, (2) one killed, two attacked at hypocotyl, and (3) three attacked at hypocotyl.

With fungus *I* (1) three stunted seedlings with brown roots, (2) and (3) healthy.

With fungus *S* (1) two healthy, one killed, (2) two healthy, one diseased and (3) one healthy, one killed and one with root system and tips of leaves attacked.

With fungus *A* (1) one healthy, one killed, one attacked at hypocotyl, (2) two healthy, one diseased, (3) two healthy, one slightly diseased.

With fungus *B* (1) one healthy, two diseased, (2) and (3) healthy.

(In the controls for *S* and *A*, a seed in one of the pots failed.)

Experiment III. A small rectangular field plot was divided longitudinally into two by a path one foot wide. On one side of this path were planted five rows of ten sets each of potato, variety "Sharp's Express." The distance between the rows was two feet and the interval between sets one foot. End on to these were planted in a similar manner five rows of ten sets each of the variety "British Queen." End on to the "British Queen" were planted five rows of ten sets each of the variety "King Edward." Next to the "King Edward" were planted five rows of broad beans, followed by five rows of garden peas. Each block of five rows was separated from its neighbour by a path two feet wide. The distance between the rows of beans and peas was one foot and each row comprised twenty-two holes at an interval of six inches, and sown with one seed per hole. All were sown in the usual manner without manure or any special treatment and served as controls. On the other side of the longitudinal path were sown similar blocks of five rows of "Sharp's Express," "British Queen," "King Edward," broad beans and garden peas. In the case of these potato sets a cylindrical piece of the flesh had been extracted by means of a cork borer and in the cavity so made a fragment of one of the fungi *E*, *I*, *A*, *S* and *B*, growing on malt extract agar was placed in each of the ten sets in a row. Thus in the five rows of each variety one row was infected with *E*, one with *I*, and so on for *S*, *A* and *B*. These rows of beans and peas were also infected with one of the five fungi by placing a small piece of the culture in contact with the seed in the soil. Sowing was done on April 7th. All the potato sets in controls and infected germinated with the exception of one set in each of two infected rows of "British Queen." The latter were examined and found to be very hard but not invaded by fungus hyphae. The failure of infections was probably due to the fact that the conditions of temperature and moisture were not suitable to the fungi. The results of germination of beans and peas are given in the table on p. 207.

Experiment IV. Previous experience in regard to the powers of *E* to infect pea and bean seedlings and the records for the

English forms in regard to their effect on potato indicate that the conditions of temperature and moisture were unfavourable to the growth of the fungi so that the results in the previous experiments were not as definite as they might have been. Another experiment was therefore carried out in the laboratory on a small scale where the above-mentioned factors could be controlled. For this purpose ten small beakers (300 c.c. capacity) were filled with soil and sterilised in an autoclave. Several cress seeds were then sown on the surface of the soil and covered with sterilised sand which would offer little resistance to the

No. of row	No. of plants in controls	No. of plants in infected	Host	Fungus	Remarks
1	17	10	Beans	*E*	Average germination
2	18	18		*I*	in controls = 17
3	15	15		*S*	
4	17	15		*A*	
5	18	18		*B*	
1	15	12	Peas	*E*	Average germination
2	15	15		*I*	in controls = 15·4
3	18	15		*S*	
4	16	15		*A*	
5	13	16		*B*	

young seedlings. Distilled water was added to wet the soil thoroughly. When the seedlings appeared above the surface they were thinned out to twelve seedlings per beaker in such a way that they were grouped fairly close together in the centre. In contact with the seedlings in one of the beakers a piece of potato on which *E* was growing was placed, and likewise *I*, *S*, *A*, *B*, *PO* and *PE*, were placed in seven other beakers. The remaining two were kept as controls. All ten beakers were grouped together and placed under a large bell-jar. In order to keep the air moist inside the jar a beaker containing water at about 90° C. was placed inside and the vapour from this condensed on the sides of the bell-jar. As in the previous experiments all cultures used were exactly the same age. In this case subcultures were made on June 7th and used for infection on June 14th. As nearly as could be judged by the eye the same amount of fungus was placed in the beakers in all cases.

With fungus *E* all seeds were healthy on the 5th day after sowing (June 19th); on the 6th day several seedlings were attacked, on the 7th day all seedlings were attacked and on the 8th day (June 22nd) all seedlings were dying.

With fungus *I* all seedlings were healthy on the 7th day after sowing but one was attacked on the 8th day, and on the 12th day this was dead and two others were slightly attacked.

With fungus *S* two seedlings were attacked on the 8th day, six were collapsing on the 11th day and all were collapsing on the 12th day.

With fungus *A* all seedlings were healthy until the 12th day when two were slightly attacked.

With fungus *B* three seedlings were attacked on the 7th day, dying on the 8th day; six more were killed by the 11th day and the remaining three were attacked on the 12th day (dying later).

With fungus *PE* several seedlings were attacked on the 5th day, all were in a collapsed state on the 6th day, and all were dead on the 7th day.

With fungus *PO* one seedling was attacked on the 8th day; all seedlings were dead on the 11th day.

All the seedlings in the controls remained healthy throughout the experiment.

The result as given in the above table gives a good indication of how these fungi stand in regard to their parasitism of cress seedlings under such conditions. It would, however, be more accurate if the results were considered from the date when the attack commenced, otherwise it is misleading in regard to *PO*, and *S*, which took a few days to commence the attack and then proceeded as rapidly as *E* and *PE*. There is no marked difference, therefore, between *E*, *S*, *PE* and *PO*, which were the most active as parasites. *B* is also an active parasite of cress seedlings but as already stated it is not such a fast grower as *E*, *S*, *PE* and *PO*. *I* and *A* are not so active as parasites. There does not seem to be any indication of a correlation between the rate of growth and the rate at which seedlings are killed since *I* is a faster grower than *B*. On the other hand, rapidity of growth does obviously assist a fungus to cause more damage than the slower grower when both are equally active parasites, *vide E*, *S*, *PE*, *PO* and *B*.

The fungi were isolated from diseased cress seedlings in all cases with a view to ascertaining whether the diagnostic characters would again be shown in culture. There was no difference in growth between any form before and after passing through cress, so it is reasonable to consider these characters as being permanent in the sense that the term can be applied to microscopic fungi.

The above experiment was repeated in all detail with the fungi *E*, *PE*, *A*, *B* and *S*, with the following results:

With fungus *E* all seedlings were collapsing on the 4th day after infection, and all were dead on the 5th day.

With fungus *PE* the results were similar to *E*.

With fungus *A* all seedlings were healthy on the 5th day, two were dead and two diseased on the 8th day.

With fungus *B* three seedlings were diseased on the 4th day,

six were collapsing on the 5th day and all were dead on the 8th day.

With fungus *S* none of the seeds were diseased up to the 8th day. Growth was very feeble, probably due to the medium becoming contaminated by rapidly growing saprophytes after the date of infection.

The above results compare favourably with those of the preceding experiment.

Microscopical Characters.

Although, as already stated, there are definite distinguishing features between the various forms when compared macroscopically, under the microscope, however, the differences are confined to the colour of some of the hyphae in old cultures. In cultures of all ages the size of the hyphae varies within the same limits in all forms. In cultures forty-eight hours old all the hyphae are hyaline and those of one form are indistinguishable from the others. In cultures fourteen days old, some of the forms show the presence of brown hyphae. These are *E*, *I*, *S*, *A*, *PO* and *PE*. On agar the colour of the brown hyphae of the fungus *E* is somewhat lighter than the others which are of a darker reddish-brown. In the case of *B* and *W* all the hyphae when examined singly are hyaline and buff in mass. In cultures seven weeks old on potato the hyphae are a mixture of hyaline and brown in *E*, *I*, *S*, *A*, *PO* and *PE*. The hyphae of *B*, on the other hand, remain hyaline when examined singly and buff or light brown in mass. This is also the case with *W* for hyphae proper but the inner tissues of sclerotia are brown.

Conclusion.

As already stated some of the above isolations are easily distinguishable macroscopically; on the other hand, some of these when examined microscopically cannot be separated from each other by any observable character. The microscopic differences observed in some cases are only slight and it is considered that they do not justify a multiplication of species. Such minor differences have been observed in the case of several other species of fungi with the result that they have been split into biological species of the same morphological species.

Matz (2) has separated into different species of *Rhizoctonia* isolations which differ between them considerably less than the two extremes *I* and *B* forms mentioned above. The minor differences described by Matz occurred in some cases when the fungi were growing on different media and if this method of determination of species were followed in this paper, the fungus *E* growing on freshly prepared agar would be a different species from *E* growing on the same medium which had been allowed to

dry slightly, and a third species would be made of *E* on potato, The one name *Corticium vagum* B. & C. = (*Rhizoctonia Solani* Kühn) is, therefore, retained for the isolations compared in this paper at the same time realising that the species contains several biological species or strains.

BIBLIOGRAPHY.

(1) Duggar, B. M. *Rhizoctonia Crocorum* (Pers.) DC. and *R. Solani* Kühn (*Corticium vagum* B. & C.) with notes on other species. Ann. Miss. Bot. Gdns. II, pp. 403–458. (1915.)
(2) Matz, J. The Rhizoctonias of Porto Rico. Journ Dept. of Agric., Porto Rico. V, No. 1. Jan. 1921.

SOME OBSERVATIONS ON FISTULINA HEPATICA AND HOLLOW, STAG-HEADED OAKS.

By K. W. Braid, B.A., B.Sc.

Few trees appeal more strongly to the popular imagination than oaks, hence their defoliation by *Tortrix* or the bepowdering of their leaves by *Oidium* offends the national eye and heart. Many, who have no hint of the causes, bemoan the appearance of the stag-headed giants of our parks and forests.

In 1921 and 1923 there was a surprising abundance of *Fistulina hepatica* Fr. on the oaks in Richmond Park. On September 8th, 1923, a stipitate specimen was found growing in the dark cavity of a hollow oak, and a few yards away on a branch of another tree a normal specimen was found. Three weeks later a count of twenty trees showed that twelve possessed ripe fungus fructifications. That is, about 60 per cent. actually bore the fungus in fruit, or, counting the two trees which had possessed sporophores on the 8th and which had been numbered amongst the selected twenty, 70 per cent. of the trees bore, or had borne, fructifications during the year. A more extended count confirmed these figures. The following day another count was made in a different part of the Park. As before, old trees were chosen which were at least two feet in diameter at three feet above ground level, and *Fistulina hepatica* was found on 75 per cent. of the trees. Sometimes the fructifications were on the buttresses of the roots, sometimes on the bark of the trunk, but usually were well up on the larger limbs. Later, in the case of an old felled stump, a *Fistulina* was seen growing vertically upon the cut upper surface near the centre of the stump. The following week in a different part of the park

attention was again confined to trees exceeding two feet in diameter, and 60–70 per cent. were found bearing sporophores of *Fistulina*, many of which were distinctly aged and often green on the top owing to the presence of an *Aspergillus* sp. The next week only two fresh fructifications could be found in this area, and many of those previously noted were now rotting away. Practically all the infected trees (only one exception was noticed) had been pollarded, and the original rot—to whatever it was due—presumably had started in the wound. In nearly all cases where the *Fistulina* was present the trees were stag-headed. Although only preliminary work has been done it is evident that the water content of the soil is not the chief factor in producing stag-headedness, for trees in the hollows are often more affected than those on higher ground. I think also that *Fistulina* is more frequent in lower-lying places. The present general opinion is that stag-headedness in trees is due to an insufficient water-supply. This may, however, be due to various causes, for example, actual lack of water, unavailability of the water, or owing to the wood vessels being insufficient for the requirements of the tree. In the writer's opinion the latter is the primary factor at work in the case of stag-headed oaks. The leaf area has adjusted itself to the supply of water which the vessels were able to supply for average years, and if exceptional causes arise (such as drought) this equilibrium is upset and those portions furthest from the supply suffer most acutely. *Fistulina* apparently plays a large part in the hollowing of oaks in Richmond Park and is possibly also one of the main factors in causing stag-headedness. Observations made by others in other parks and forests would give data of value for the future.

The following is an instance of the effects of the hollowing upon the root system of an oak. A specimen of *Quercus Phellos*, felled at Kew recently as being dangerous, had been hollowed by a polypore. The fungus, however, had not produced fructification sufficiently well developed for certain identification. In this particular case the root was extracted and showed certain noteworthy features. The internal hollowing extended right down the stem to the soil. The original roots which had supplied the tree for the first few decades had rotted away. The roots which appeared to exist from an observation of the buttresses prior to felling were in fact non-existent and their place had been taken by a number of smaller subsidiary roots which in most cases had arisen from the upper surface of the original buttress root. None of these subsidiary roots exceeded eight inches in diameter. The centre of the tree being rotten or extinct the thin, living shell had developed its own, relatively young root system, which, being small, had a limited range of soil to

explore. It seems probable that the bulk of the living root system in such cases is confined to ground already sheltered by the leaf canopy and consequently deficient in water supply and impoverished in nutritive material. The whole of the area beneath the tree is not short of water; during wet weather water trickles down the bole of the tree and saturates the area in its immediate vicinity: the finer roots doubtless make good use of this supply, and its presence may encourage additional adventitious roots in this area. This problem requires more experimental investigation. Unfortunately the roots of the hollow trees in Richmond Park are not grubbed up, so there has been no opportunity of studying their root systems. Any mycologist able to investigate such root-systems would confer a great boon on his physio-mycological brethren by publishing notes on such examinations: it is with a view to eliciting such assistance that the present observations are published.

No brackets of *Polyporus dryadeus* have been found on oaks in Richmond Park but Dr J. W. Munro called my attention to white woolly masses of mycelium in some heart wood which suggested this fungus. Occasionally signs of polypores have been seen but not in a state sufficiently developed for critical determination. Rhizomorphs of what appeared to be *Armillaria mellea* Vahl. were seen on one or two occasions; and on one dead butt fructifications of *Armillaria mellea* were found.

An examination of the root systems of a number of hollow trees—including an Elm hollowed by *Fomes ulmarius* and others by fungi bearing no sporophores—has in every case shown abnormal development of fibrous roots under the leaf canopy and decay among the larger roots. These facts have suggested the following hypothesis as to one of the causes of stag-headedness of oaks after weak, parasitic, fungoid infection. If the infection has gained entrance *via* a branch wound and has assisted in the decay of the heart wood while exploring the less vigorous cells of the living sap-wood, then the mycelium gradually extends first down the centre of the trunk and later along the main roots. Following the advance of the fungus the attacked tissues would decay and become hollow. When such hollowness extends right down into the earth penetrating the lower portions of the main root (as it does) then the food in solution conveyed by the vessels in the lower parts of these roots either is wasted or in very small part utilised by the adjacent healthy cells which are still in direct connection with the xylem strands of the stem. The oak ceases to obtain a large proportion of the liquid nourishment it previously received and suffers in consequence. The phloem stream also would be interfered with and consequently the lower portions of the main roots are least

able to cope with the advance of the mycelium and become destroyed quickly. Callus growth would be encouraged between the healthy wood of the main roots and the diseased wood and it is thought that the fibrous roots which develop in such cases would arise in the first place from such a "callus area." Possibly the accumulation of food from the sound, but now severed, phloem cells causes the gouty appearance round the base of the trunks and on the buttresses of the main roots, and may also assist in giving rise to the abundance of adventitious roots which ultimately grow from the upper surface of the main roots. Part of the stem is thus no longer in direct connection with the wood and bast elements of the lower portion of the main roots, and the holes and rifts which frequently arise at such places giving access to the hollow interior of the tree show that the fungus makes a special onslaught on this portion of the stem.

TREE MYCORRHIZA.

(Chiefly Field Notes.)

With Plates XI and XII.

By Robert Paulson.

The close association of a fungus with the rootlet of a higher plant produces the phenomenon known as mycorrhiza or fungus-root, a condition that occurs abundantly, almost without exception, on the roots of *Quercus Robur*, *Fagus sylvatica* (1) fig. 1, *Carpinus Betulus* (1) fig. 2, *Betula alba*, *Castanea sativa* fig. 3, *Pinus sylvestris* and *Taxus baccata* in woodlands of the south-eastern counties, especially in those located on a light soil.

The south-eastern counties are mentioned for the reason that the writer's observations on fungus-roots have been carried on mostly in that part of the country.

Mycorrhiza is developed to its fullest extent upon roots that do not enter the soil but spread out horizontally throughout masses of decaying leaves which accumulate in depressions of the ground near tree trunks. Should there be carpets of moss on the more level ground, such as those formed by *Mnium undulatum* and by the coalescent cushions of *Leucobryum glaucum*, roots of trees grow upwards into the lower, decaying layers of the moss and there develop the state of mycorrhiza.

Figs 1, 2 and 3 each represents a horizontal plane as seen by an observer on bending forward to look upon the ground. All that was necessary when preparing to expose the photographic plate was lightly to remove, preferably with the fingers to avoid disturbance of the roots, the topmost layer of the leaves to a

depth of 1·5 to 2·5 inches. The roots were growing in a series of layers, one below the other, the number in each series depending upon the thickness of the accumulated leaves. The upper layer is, as a rule, the best for illustrative purposes.

Any hypothesis advanced respecting the exact relation that exists between the root of the tree and the fungus must take into consideration the fact that the bulk of the mycorrhiza met with in woodlands is formed among decaying leaves, of which the progress of decay is not greatly advanced, and also, that mycorrhiza is abundant a very short distance below the surface of the leaf mass.

The above statements are emphasised because, during a period of drought even of short duration, the conditions, represented (figs. 1, 2 and 3) as normal, are completely changed by the mycorrhiza being desiccated and thereby killed.

Mycorrhiza does not revive after being destroyed by the lack of moisture and does not reappear on the return of copious rain until new rootlets have been developed and they in their turn have become associated with a fungus.

Provided a drought is not sufficiently prolonged to destroy the thicker roots, on which are the finer ramifications, new fibres are produced in abundance, on the return to normal atmospheric conditions, among the same leaves where mycorrhiza formerly existed and where fresh fungus mycelia have already appeared. No evidence has been observed of any tendency on the part of newly formed rootlets to avoid fungus hyphae, with which they soon become associated. A root-system is developed and spreads through the leaf-masses where fungus mycelia are abundant. In the case of roots that enter the lower layers of a moss carpet there is indication of a definite tropism as the moss forms a nidus for numerous fungi and roots turn upwards from the soil into it and subsequently develop mycorrhiza.

In the field, the collector needs very little special apparatus. A scout's knife, test-tubes of one inch diameter or bottles of 2 oz. capacity, a pocket lens and the ordinary vasculum are all that are required. On no account must the material be exposed for even a short period to a dry atmosphere. The test-tubes or bottles should be filled with water for examination and for safe transport. On placing a portion of mycorrhiza in a tube of water, it is possible to determine with a pocket lens the form, colour, and general appearance which may be wax-like or shaggy; points which must be taken into account when deciding whether to keep or to reject material.

The mycorrhiza of beech *in situ* (fig. 1) shows (1) the horizontal growth of roots through a loose layer of leaves which are in an

early stage of decay, (2) an abundance of intertwining hyphae, many of which are attached to roots.

Close observation is necessary before rootlets can be detected that are not in a mycorrhizal condition. The mycorrhiza of hornbeam and sweet chestnut (figs. 2 and 3) exhibit respectively characteristics similar to those of fig. 1, but there are small differences of detail.

A clump of moss is a most favourable nidus for the germination of birch seeds and those germinating naturally under such circumstances, as great numbers do, are found to develop mycorrhiza at a very early period of their existence, viz. before the cotyledons have ceased to function, while the stem is yet little more than half an inch in height, and before the radicle has passed through the lowest layer of the moss carpet.

The birch seedling illustrated in fig. 4 was collected on 13th October, 1923. Its trilobed, lower leaf indicates the first year of growth and as it germinated most probably in the previous April it is probably six months old. The whole of the root system is mycorrhizal, and in this case is of two kinds, one of a dark gray colour and the other of a white slightly shaggy appearance which we associate with the fly agaric, *Amanita muscaria*.

Three to four states of mycorrhiza, differing in form, size, texture and colour, occur on the same species of tree and quite frequently two forms appear on an identical root-branch.

The most common mycorrhiza of beech is dark brown in colour and wax-like in appearance. These characteristics give no clue to its fungal origin. Besides the above, a yellow and a white mycorrhiza are frequently met with on the roots of this tree. The latter being shaggy, it is possible, on examining it in a tube of water, to see with a pocket lens of low magnifying power loose hyphae extending from its surface in all directions. These hyphae come into contact with decaying leaves to which they adhere, but in the case of the wax-like form actual contact with the humus matrix is restricted considerably.

The mycorrhizal roots of *Pinus sylvestris* are coralloid, that is, the branches of the root are short, closely clustered, and being pinkish in colour somewhat resemble coral. The branches are mostly furcate at the extremities, and average 4 mm. in length and 0·5 mm. in diameter.

In attempting to establish the mycelial connection between mycorrhiza and the sporophore of a *Basidiomycete* (fig. 5) frequent failure results. A mycelium may break and when it is white and is mixed with many similar ones it is scarcely possible to be sure of catching up the right thread. A case has been recorded of following up a coloured mycelium for a distance of 54 dec.m. = 17·7 ft. (2) In a great majority of cases the

mycorrhiza is only one to three inches from the toadstool with which it is associated.

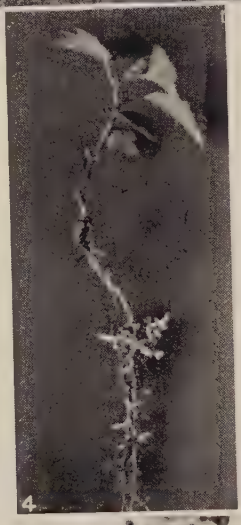
A method that has given satisfactory results is that of cutting a circle through the surrounding leaves and other debris to a depth of three inches at a radius of six inches from the stipe of the sporophore, and then, working from opposite points with the fingers of both hands until the whole mass can be lifted from its surroundings. Such a mass with the base of the stipe attached can be carried without danger of disturbing the roots within. Having severed a number of roots during the cutting of the circle it is possible to trace one that comes from near the centre. By carefully removing the material attached to the root it is possible to demonstrate the connection, by means of a mycelium, between the mycorrhiza and toadstool.

The stages in the formation of mycorrhiza from a normal root have not been seen, but observation of roots after heavy rain, which followed dry weather, has been sufficient to enable the writer to conclude that new rootlets followed by a complete change to mycorrhiza have developed within ten days.

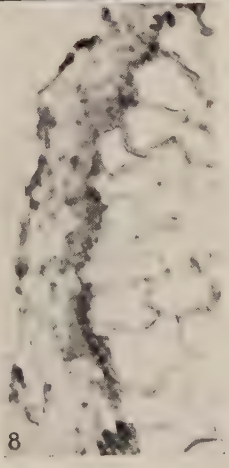
Peyronel (3) has recorded the association of a large number of Basidiomycetes with the roots of forest trees. His list includes for Beech, *Cortinarius proteus, Boletus chrysenteron, B. cyanescens, Scleroderma vulgare, Amanitopsis vaginata, Lactarius subdulcis*; for Sweet Chestnut, *Amanita rubescens, Russula lepida, R. rubra, Scleroderma vulgare*; and for Birch, *Tricholoma flavobrunneum, Amanitopsis vaginata, Amanita muscaria, Boletus scaber, B. radicans, Scleroderma vulgare.*

A transverse section of the dark brown mycorrhiza of birch (fig. 6) has a diameter of 0·35 mm. It exhibits a series of three concentric circles the outer of which, the mantle, *a* consists of hyphae so closely compact that they form a plectenchyma similar to that of the upper surface of some foliose lichens. Within the mantle are the cortical tissue *b, c, d* and the central axis *e* of the birch root. The epidermis appears crushed and root hairs cannot be traced. The outer cells of the cortex are elongated radially. Hyphae, that have, by the secretion of an enzyme, dissolved the middle lamella may be seen between the cortical cells to have entered the cortex to a depth of three to four cells. Occasionally one of the hyphae is seen to have penetrated a cell-wall and to have developed a vesicle at its extremity (fig. 7 *a*). Such a vesicle is of the nature of a haustorium but the fact that this development is so rarely met with prevents one from basing any theory upon its presence. It is sufficient for our present purpose to note that haustoria do occur.

The object of these notes, which for the most part are based on field observations, is to suggest that investigation following



5



8

the lines indicated may assist in the elucidation of the hitherto unsolved question of the true relation that exists between the fungus and the root in the case of ectotropic mycorrhiza.

Recent literature (1912–1922) points clearly to the fact that from a biochemical and microchemical standpoint investigators differ widely in the interpretation of the results of their work (4). On the one hand it is maintained that the relation between tree and fungus is that of parasitism only on the part of the latter, while on the other hand it is regarded as symbiosis in the broad sense of the term.

Field studies afford considerable evidence in favour of the view that the relation is something more than that of parasitism and that it is mutual or symbiotic.

Summary.

(*a*) The association with a mycorrhizal fungus commences, in the case of birch, while the seedling is very young, almost immediately after germination, and it exhibits no indication of injury, accruing from the fact that the whole of its root system immediately developes mycorrhiza.

(*b*) The whole of the water absorbed by such a seedling must pass through the mantle. It contains dissolved colloid substances from the surrounding matrix. Water is readily absorbed and readily yielded by the mantle.

(*c*) Roots of woodland trees, oak and beech, for example, creep over the surface of the soil, where there is an abundance of moss, and entering the lower layers of the moss carpet develop mycorrhiza. A chemotoxic action is apparently set up within the decaying moss.

(*d*) There are indications that in cases of severe drought when much mycorrhiza has been destroyed, certain trees, notably, birches of all sizes, and hornbeam stools, lose vitality and become specially subject to attacks from microfungi such as *Melanconis stilbostoma* (Fr.) Tul. and *Pseudovalsa lanciformis* (Fr.) Ces. and de Not. (5).

I am much indebted to Dr Somerville Hastings for the photographs of mycorrhiza *in situ* and to the Essex Field Club for the loan of two blocks.

References.

(1) Peklo, J. Epifytické mykorrhizy. II. *Carpinus Betulus* a *Fagus silvatica*. Rozpravy České Akademie, etc. Třída II, Ročník. XIX (1910). Číslo 35.
(2) Noack, F. Über mykorrhizenbildende Pilze. Bot. Zeit. XLVII, p. 389 (1889).
(3) Peyronel, B. Nouveaux cas de rapports mycorhiziques entre Phanérogames et Basidiomycètes. Bull. Soc. Mycol. Fr. XXXVII, p. 143 (1921).
(4) Ramsbottom, J. Orchid Mycorrhiza. Trans. Brit. Mycol. Soc. VIII, p. 28 (1922).
(5) Paulson, R. An Enquiry into the causes of the death of Birch Trees in Epping Forest and elsewhere. Essex Nat. XI, p. 273 (1900).

EXPLANATION OF PLATES XI AND XII.

Fig. 1. Horizontal view of mycorrhiza of Beech.
Fig. 2. Horizontal view of mycorrhiza of Hornbeam.
Fig. 3. Horizontal view of mycorrhiza of Sweet Chestnut.
Fig. 4. Birch seedling; the entire root system is mycorrhizal.
Fig. 5. Lower portion of the stipe of *Amanita muscaria* over the root of birch, showing hyphal connections between stipe, *s*, and mycorrhiza, *m*.
Fig. 6. Transverse section of mycorrhiza of birch. *a*, mantle; *b*, radially elongated cell of cortex; *c*, unmodified cells of cortex; *d*, endodermis; *e*, central axis. × 200.
Fig. 7. Portion of outer layers of the cortex showing vesicle (*a*) within the lumen of a cell. Hyphae from the inner layer of the mantle can be traced to a depth of three layers of the cortex. × 410.
Fig. 8. Portion of the mantle, *m*. × 410.

THE LIFE HISTORY OF POLYTHRINCIUM TRIFOLII KUNZE.

(With Plate XIII.)

By Jessie S. Bayliss-Elliott, D.Sc. and Olive P. Stansfield, M.Sc.
University of Birmingham.

Polythrincium Trifolii, a Hyphomycete usually classified in the Cladosporieae, has a cycle of development the knowledge of which has, up to the present, been mainly a matter of conjecture. The fungus was described by Kunze (12) who remarked at the end of his description: "Von einigen Botanikern erhielt ich diesen, keinesweges seltenen, Pilz, für *Sphaeria Trifolii* P." Persoon's description (13) of the latter is as follows: "*Sphaeria Trifolii*: atra parva, magnitudine varia, cespitulo inaequali ruguloso interne subpulverulento....Sphaerulae farctae, intus albicantes." Fries (9) adds to Persoon's diagnosis that the perithecia are immersed in stromata and suggests that the species might better be placed in the genus *Dothidea*, a transference which he afterwards made (10). Fuckel (11) regarded these two fungi as stages in the life cycle of an ascomycetous fungus which he considered as a species of *Phyllachora*. "Fungus conidiophorus. *Polythrincium Trifolii* Kze....Fungus spermogonium. Sphaeria T. Pers. Dothidea T. Fr. Spermatiis minutissimis, cylindraceis, curvatis, ascillantibus. Fungum ascophorum nondum vidi." Fuckel's name and the suggestion that these were stages in the life cycle of the fungus have been generally adopted in systematic works. In the present paper we are able to show that there are three such stages but the perfect condition is not a species of *Phyllachora* but of *Dothidella*.

As far as we are aware the Pyrenomycete stage of this fungus

has never previously been recognised. It is true that Cooke (6) describes such a stage with "Ascis clavatis. Sporidiis ellipticis, continuis, hyalinis, ·01–·012 × ·005 mm. From specimen in Herb. Berkeley," but an examination of the specimens in the Kew Herbarium has not revealed such a stage. It is possible that he was dealing with a fungus other than the one under discussion. Clevenger (5) recorded mature asci and ascospores in specimens he named *Phyllachora Trifolii* (Pers.) Fuck. on *Trifolium wormskioldii*. Theissen and Sydow (14) regard these specimens as a new species which they call *Phyllachora umbilicata*. (Incidentally it may be remarked that these authors state that they have examined specimens of *P. Trifolii* from many places but have never found asci; the European specimens distributed under this name, however, are identical with the type specimen of *Sphaeria Trifolii* Pers. which they have examined.)

1. *Conidial Stage.* Leaves of *Trifolium repens* affected by *Polythrincium Trifolii* were found at Tanworth-in-Arden, at the end of October, 1920. The fungus attacks the under surface of the leaves, producing olive-brown to black cindery patches, consisting of punctiform stromata crowded together, which gradually coalesce to form the characteristic relatively large stromata (1 × ·5 mm. or less). During this stage of the life of the fungus the leaves remain green, but fade later. There is no colour zonation round the black stromata, indicating progressive destructive action of the fungus such as is seen when *Pseudopeziza Trifolii* grows on the same host. The yellow tissue surrounding the black spots to which Kunze (2) refers has not been seen. The leaflets of the infected leaves take an upright position and are thus easily distinguished from healthy leaflets which are extended horizontally. It is, of course, not uncommon for leaves attacked to assume an abnormal position, the phenomenon being perhaps best seen in the rusts. Finally the whole clover leaf withers and when it has fallen to the ground soon decays. The fungus is apparently attractive as food to certain insects, as leaves are frequently found spotted with holes, marking the position of eaten stromata.

In surface view, under low magnification, the stromata appear to be powdery, owing to numerous spores on the crowded conidiophores, which have burst through the cuticle of the leaf (fig. 1). Stromata, which are easily found in different stages of development, arise in two different ways; either by infection from a conidiospore, pycnospore or ascospore, or by infection from hyphal branches, arising in a stroma already present. In both cases the first signs of infection are very similar; a few fuscous hyphae, often developing beneath a stoma, form a plate-like mass of parenchymatous cells and from these the conidiophores

arise (fig. 3). When infection is due to a spore the stromata are at first isolated; otherwise they are connected to other stromata by strands of hyphae, which have made their way underneath the epidermis of the leaf, usually as far as a stoma (fig. 2). The hyphal strands are of different lengths, sometimes very short indeed, so that the new stromata coalesce with the parent. From each cell of the young, plate-like stroma an erect hypha is produced, wavy in outline, which ultimately becomes a conidiophore (fig. 1).

Groups of characteristically waved conidiophores (fig. 1) burst through the cuticle, having destroyed and replaced the epidermal cells. Each conidiophore produces a large obovate uni-septate spore, which is so large (20–22 × 11–15 μ) that it appears to be slightly top-heavy. Many spores drop off and lie around the bases of the conidiophores. The conidiophores show two parts, a waved upper portion and a straight basal portion, and generally a septum separates the two parts. The upper waved portion is always a darker colour than the basal part. The stroma is not buried deeply in the mesophyll of the leaf, but only extends into the first two or three layers of cells. The thickness of the stromata varies, some stromata being several cells deep, others (usually young) forming a plate one cell deep, but even this may bear conidiophores (fig. 1). The hyphae composing the stromata are olive-brown, broad, and many-septate, giving it a pseudoparenchymatous appearance. Hyphae do not ramify extensively through the leaf, but merely extend peripherally into the neighbouring cells and produce fresh stromata. At first the hyphae progress intercellularly, the middle lamella being dissolved; afterwards the mesophyll and epidermal cells with which they are in contact are consumed and the hyphae occupy the space.

The specimens of *Polythrincium Trifolii* which have been examined have always differed somewhat from those described by Kunze (12), who considered the conidiophores to be "septate structures, whose individual cells were four-cornered with rounded ends." He also mentions the occurrence of "double grains" at the base of the stroma—evidently the two-celled conidia which have fallen off the conidiophores and are clinging about their bases. Most authors follow the original description and refer to septate conidiophores; we do not find septa in the undulating upper portion. It is strange that the error should have been persisted in as Corda pointed it out so long ago as 1839, in the work in which the drawing of the fungus occurs which has been copied so widely (8).

Hanging drop cultures of conidia were made in tap water and weak cell sap extract at ordinary room temperature in

July, 1921, but only 10 per cent. of the conidia germinated. The germ tube is at first colourless. Many instances were seen of conidia germinating on leaves taken from infected plants and twice germ tubes were seen penetrating stomata. Further, the host was also seen to be entered by a germ tube penetrating the cuticle of an epidermal cell. Here penetration occurred as in the penetration of *Vicia Faba* by *Botrytis cinerea* as recorded by Blackman and Welsford, *i.e.* without the formation of any appressorium (3): these authors suggest the cuticle is ruptured mechanically by the pressure of the tip of the germ tube. Attempts were made to infect clover plants grown in pots in a greenhouse and also plants in their natural surroundings, but none was successful. The failure of these experiments suggests that conidia do not readily infect plants except perhaps under specialised atmospheric conditions, and no doubt the physiological condition of the leaf plays an important part. It has been noticed that infection does not spread rapidly amongst clover plants in the field; since, under all weather conditions, although plenty of infected leaves could be found in the infected area, the disease was not present in anything approaching an epidemic form during the two and a half years that the plot was observed carefully.

In July, 1921, a clover leaf just showing traces of infection was placed in a room with its petiole in a glass of water and kept under observation for seven days. When first examined the leaflet was found to have five small specks, denoting conidial stromata; apart from this it was quite healthy. A week later the whole leaflet had become very pale, except for the midrib which remained green, and the leaflet was found to be covered with black conidial stromata, bearing conidiophores and obovate conidia. Three of the five original compound stromata (*a*, *b* and *c*) were especially watched, their increase in growth recorded after five days being as follows:

Compound stroma	Date	No. of infection spots	Remarks
a	July 7th	17	—
	,, 11th	30	Area nearly doubled in five days
b	,, 7th	3	Stroma tumid and colourless, one infection spot mature and black, the rest colourless
	,, 11th	17	Original infection had sent out 14 hyphae to produce 14 fresh infection spots, and had increased in area nearly six times
c	,, 7th	7	Stroma colourless, infection spots black
	,, 11th	36	Stroma entirely black, from one infection spot a tendril of pycnospores was exuding

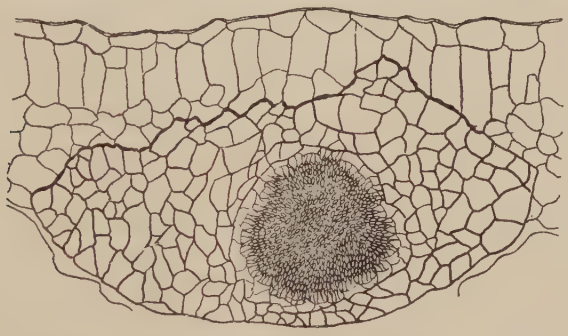
From these results it is evident that conidial stromata form rapidly and mature quickly, the conidia being produced with considerable speed.

2. *Pycnidial Stage.* In autumn the fungus enters upon another stage in its development. Amongst the conidial stromata other stromata are to be seen, which are black and shiny, instead of powdery, and lie mostly under the cuticle of the leaf. A low magnification shows a number of papillae arising from the stromata in a dark, rugose mass and marking the position of developing pycnidia. At the apex of some papillae may be seen a small orifice, through which pycnospores have been discharged. The number of papillae arising from a stroma varies greatly according to age. In the older and larger stromata as many as thirty pycnidia are often present. The stromata may be as large as 2 × 1 mm., but they vary in size considerably.

Pycnospores are produced in great numbers from the interior of the pycnidium, and when mature, are discharged in tendril-like masses. The spores are oval and hyaline, and measure 5 × 1·5 μ. Pycnidial stromata are produced either by the formation of a stroma at the end of a hyphal branch coming from a conidial stroma or by the actual conversion of conidial stromata into pycnidial stromata. In the first case the hyphae extend horizontally a few cells from the parent stroma and each sends out a mass of short, septate, hyphal branches, which form a dense stroma having the usual pseudoparenchymatous appearance. These pycnidial stromata extend more deeply into the mesophyll of the leaf, sometimes even reaching the upper epidermal surface. The lower epidermal and mesophyll cells are destroyed by the fungus, the cuticle of the leaf alone covering the stroma until maturity. In the second case the conidial stroma extends further into the mesophyll, the hyphae become more septate, and the whole stroma assumes a denser structure. Most of the conidiophores break off at the level of the epidermis of the clover leaf, and the stroma now presents the rugose, papillate appearance already described; but usually there are traces of the waved conidiophores characteristic of ordinary conidial stromata. In one instance a pycnidial stroma was found on the upper surface of the leaf, lying close to the midrib, and connected by a thin weft of hyphae to a pycnidial stroma on the lower surface.

Pear-shaped pycnidial cavities are produced in the stromata in great numbers, and are often only separated from one another by a narrow wall of dark pseudoparenchymatous cells (fig. 5). The first indication observed of a pycnidium is a colourless pseudoparenchymatous mass of cells in amongst the darker hyphae and below the surface. This mass of cells increases in

size and reaches nearly to the surface of the stroma, appearing in surface view as a whitish spot in the black stroma. After attaining the typical pear-shaped form these cells gradually disintegrate and many minute oil drops are often to be seen exuding from the ostiole which is formed at the apex of the pycnidium at this time (fig. 5). Many of the oil drops are curved and resemble small spores. They were probably mistaken for the pycnospores by Fuckel (11) who does not give their size, but merely comments on their minuteness and their Brownian movement. The lining layer of cells produces on its inner surface very many ampulliform cells, which may be considered to be conidiophores. Ampulliform conidiophores similar to these occur



Text-fig. Pycnidial stroma cut through pycnidium bearing pycnospores. × 215.

in many Fungi and also in Lichens. From the ampulliform conidiophores long chains of oval conidia are formed in basipetal succession. The entire pycnidium becomes filled with conidia embedded in mucilage, which will absorb water and swell up, thus extruding the spores in the form of a tendril through the ostiole.

In hanging drop cultures in tap-water and weak cell-sap extract pycnospores merely budded like yeast; budding was observed also on infected leaves, as well as germination in the normal manner.

In October, 1921, plants of *Trifolium repens*, growing in a field were infected with pycnospores which after being stirred in a drop of sterile water were transferred by means of a fine brush to the under-surfaces of leaves in various stages of growth. After three weeks most of the leaves showed the characteristic black stromata bearing typically waved conidiophores with large obovate uniseptate spores; several also showed pycnidial stromata in early stages of development. Mild autumnal weather with occasional showers of rain prevailed throughout

the experiment. Pycnospores evidently can infect the clover host more readily than conidia. Leaves infected by pycnospores after being fixed (alcohol and formalin), microtomed, and stained (haematoxylin), were examined for signs of infection and it was seen that germ tubes usually entered the host by penetrating the cuticle of the leaf but in one instance a germ tube was seen entering through a stoma.

It is evident that infection does not spread rapidly over large areas, so the question arises as to how the conidia and pycnospores are distributed. The conidia are large and heavy and after falling cling somewhat persistently about the bases of the conidiophores. It is therefore concluded that they are not dispersed to any great extent by wind, although this is probably the chief means by which they are scattered. Rain will wash them about on the same leaf, but not often on to other leaves, so that there are very small chances of an epidemic of this fungus caused by conidia. In view of the enormous numbers of pycnospores which are produced, hundreds of thousands in one pycnidium, these might be expected to cause a rapid spread of the disease. The pycnospores are considerably smaller and much lighter than the conidia, and could easily be carried about by the wind. But the spores are for the most part discharged only in tendril form suffused with mucilage, and only into a humid atmosphere, hence they are not in a condition to be easily carried by the wind; however, when dry, the wind might act as an agent of dispersal. Water freely disperses the spores, and in this way they are washed from one leaf to another, but even so, the area affected can only be small and very restricted, and uninfected plants a few yards away are quite likely to escape infection. On this account it is not surprising that the disease does not spread rapidly.

3. *Ascophorous stage.* It had been noticed that after the pycnidial stage had reached maturity, the clover leaves withered, and finally fell to the ground, where they rotted or were dragged into the soil by worms, etc. As a result it was impossible to study the further development of the stromata until means were taken to prevent the disappearance of decaying leaves.

Leaves showing the pycnidial stage of the fungus were placed between large ivy leaves, and buried in soil in flower pots. Ivy leaves were used because they rot very slowly, and it was thought that even if the clover leaves rotted away completely, the black stromata might be found lying between the ivy leaves, and that though the stromata are so minute (·2–1 mm.) they would not be lost in the soil. These pots were placed out-of-doors, so as to be under natural conditions. After a fortnight, one of the pots was brought into the house for eleven days, and

kept at a cool temperature, the soil remaining damp. When one of the leaves was examined, a tendril was seen to be exuding from the ostiole of one of the stromata. The exudation was transferred to a slide for microscopic examination, and an ascus containing eight large spores was found embedded in the mucilage. The spores measured 19 × 10 μ, and contained two large guttulae. The spores were left in a damp condition, but even after 48–72 hours, there was no sign of germination. The leaflet from which the exudation was taken was sectioned in order to observe the method of growth of the asci and perithecia. Perithecial cavities containing ascogenous tissue were found in abundance, but there was no sign of a mature perithecium. The leaves were again placed between ivy leaves, and put out of doors for examination later in the season. On November 22nd, 1921, three other pots were prepared in the same way, each containing six clover leaves. On December 6th, one of these pots was brought indoors to dry slowly (as drying might perhaps stimulate the formation of ascospores), and examined after four to five weeks, but there was no sign of mature asci. On January 29th, 1922, another pot was examined, but again there were no mature asci. The leaves were replaced and the pots kept moist in a cool greenhouse for several weeks. On January 31st the pot which had previously shown ascospores was again inspected but there was no trace of clover leaves or stromata, this doubtless being due to the partiality of soil animals for the fungus. It was now thought advisable to place the clover leaves of the pots previously examined between cover slips or glass slides before burying them, so that on the disintegration of the leaf the stromata could be found easily. On February 23rd, a portion of a stroma from one of the clover leaves which had been placed between cover slips was examined and asci were found containing spores which were not quite mature. The asci grew in clusters from the base of the perithecium (fig. 6). The spores in the asci were more or less biseriate, and uniseptate and granular (being not fully mature) and measured from 24–26 × 7–8 μ (fig. 6); no paraphyses could be seen. Some of the material from which the stroma had been taken was fixed in Bouin's fluid, embedded in wax, microtomed and stained in iron-alum haematoxylin. The rest of the material was replaced between cover slips and buried between ivy leaves in soil, when further development took place and finally mature ascospores were obtained.

The stromata bearing ascogenous tissue are very similar to the pycnidial stromata, in fact perithecia occur in the same stromata as pycnidia. No trace of any archicarp has been found, the first indication of primordial perithecial tissue being a few

colourless pseudoparenchymatous thin-walled cells which doubtless arose from a single hyphal cell amongst the dark fuscous brown hyphae composing the stroma: these perithecial primordial cells stain deeply with iron-alum haematoxylin and are larger in size and less delicate than the pseudoparenchyma which initiates the formation of a pycnidial cavity. This pseudoparenchymatous mass of cells gradually increases in size and though at first somewhat pear-shaped becomes more oval and is elongated in the direction of the outer surface of the stroma (fig. 7), where ultimately, at maturity, an ostiole with projecting hairs appears. At an early stage the cells in the centre and lower part of this tissue begin to break down leaving multinucleate protoplasts which tend to arrange themselves parallel with the perithecial wall (figs. 7, 8). The cells forming the lining of the basal part of the perithecium are now seen to be richly protoplasmic and although multi-nucleate some of the nuclei in them are larger than others and appear to be paired—such cells giving rise to ascogenous hyphae (fig. 9, *a*, *b*). The ascogenous hyphae are of the hooked type and in these could be seen paired nuclei which had presumably arisen by conjugate division of the paired nuclei of the basal cells from which they arise (fig. 9); these hyphae much resembled those figured by Claussen (4) for *Pyronema confluens*.

Ascus formation from a penultimate cell could be seen (fig. 9*a*). Early stages of an ascus showed the usual paired nuclei in the base of the ascus; later, the nuclei moved towards the centre and in older asci the fusion nucleus occupied this position (figs. 9*a* and 7). As the asci develop they push aside the disorganising primordial pseudoparenchyma and occupy the space and doubtless are nourished at the expense of the products of the disorganised cells (fig. 7). At a still later stage the fusion nucleus is replaced by eight smaller nuclei which become the centres of spore formation. Towards the periphery of the perithecium many periphyses develop which bend upwards and later outwards. By the presence of these protruding periphyses developing perithecia could often be distinguished from developing pycnidia.

The life history of this fungus shows points of similarity with the life histories of other Ascomycetes. The conidial stage prevails during summer and early autumn, and is followed in later autumn by the pycnidial stage; during winter the stromata on the decaying leaves lying on the ground are set free and behave as sclerotia, in which perithecial structures develop, and thus by spring or early summer ascospores are mature and no doubt are ejected from the asci on to young clover leaves, thus causing the re-appearance of the disease.

Systematic Position. On account of the fact that the ascospores are uniseptate and the cells equal in size the fungus is best placed in the genus *Dothidella.*

DOTHIDELLA TRIFOLII

Status conidicus. Polythrincium Trifolii, Kunze—stromatibus in pagina aversa folii atris, carbonaceis, punctiformibus, deinde coalitis. Conidiophoris tortuosis, exquisite undulatis, fuscis, eseptatis, fasciculatis, erumpentibus, conidia singula, obovata brunneola, uniseptata, 20–22 × 11–15 μ, apice gerentibus.

Status pycnidicus. Sphaeria Trifolii Pers.—Stromatibus compactioribus, obscure fuscobrunneis, pseudoparenchymaticis; ovalibus, achrois, hyalinis, 5 × 1·5 μ, conidiophoris papillatis suffultis.

Status ascophorus. Dothidella Trifolii—Peritheciis in stromatibus iisdem vel similibus evolutis, ampulliformibus; ascis e basi oriundis, clavatis, leviter flexis, 8-sporis aparaphysatis. Sporidiis plus minus biseriatis, irregulariter fusiformibus, achrois, 1-septatis, 24–26 × 7–8 μ, loculis aequalibus.

Hab. in pagina aversa foliorum *Trifolii repentis,* Tanworth-in-Arden, prope Birmingham.

GENERAL CONCLUSION.

Polythrincium Trifolii develops a rather loose stroma on the under surface of leaves of *Trifolium repens* and produces during the course of its life history more compact and deeply seated stromata, which bear pycnidia containing pycnospores (*Sphaeria Trifolii* Pers.) capable of infecting fresh clover plants. These stromata, on the decay of the leaf, fall to the ground and function as sclerotia. On further growth perithecial cavities are produced, containing the asci and ascospores characteristic of a *Dothidella,* and not of *Phyllachora* as has been assumed by various authors.

In conclusion we wish to express our sincere thanks to Mr W. B. Grove, M.A., and to Professor Yapp for much valuable help and criticism during the course of this work.

POSTSCRIPT.

Since the above was submitted for publication a paper by Ch. Killian entitled "Le *Polythrincium Trifolii* Kunze parasite du Trefle" has appeared in Rev. de Path. Veg. et d'Entom. Agric. x, pp. 202–219 (1922). According to this writer the perithecia commence to develop at the same time as the pycnidia. The development of the perithecia is very slow but may be accelerated by burying infected leaves in fine sand in a warm atmosphere and watering daily; if, on the contrary, they are placed out of doors on damp cotton wool development is not

complete until spring. Leaves placed in muslin bags on the surface of the soil decomposed completely after a few weeks without leaving any traces.

The perfect stage of the fungus obtained by Killian is the same as that described above but he calls it *Plowrightia Trifolii*. *Dothidella* Spegazzini (1880) has priority over *Plowrightia* Saccardo (1883) (v. Theissen and Sydow, p. 309) and the subject of our investigations must therefore be known as *Dothidella Trifolii*.

REFERENCES.

(1) Bayliss-Elliott, J. S. and Stansfield, O. P. Gardener's Chronicle, ser. 3, lxxiii, p. 221 (1923).

(2) Blackman, V. H. and Welsford, E. J. The Development of the Perithecium of *Polystigma rubrum* DC. Ann. Bot. xxvi, p. 761 (1912).

(3) —— Studies in the Physiology of Parasitism. II. Infection by *Botrytis cinerea*. Ann. Bot. xxx, p. 389 (1916).

(4) Claussen, P. Zur Entwicklungsgeschichte der Ascomyceten, *Pyronema confluens*. Zeitschr. f. Bot. iv, p. 35, Taf. 4 (1912).

(5) Clevenger, J. F. Journ. Mycol. xi, p. 160 (1905).

(6) Cooke, M. C. Grevillea, xiii, p. 63 (1885).

(7) Corda, A. J. C. Pilze in Sturm, J. Deutschlands Flora. iii, Hft. 10, p. 17, tab. 9 (1830).

(8) —— Icones Fungorum, iii, p. 10, Tab. II, fig. 25 (1839).

(9) Fries, E. Syst. Mycol. ii, p. 435 (1823).

(10). —— Summa Veg. Scand. p. 387 (1846).

(11) Fuckel, L. Symb. Mycol. p. 218 (1869).

(12). Kunze, G. and Schmidt, J. K. Mykol. Hefte, i, p. 13 (1817).

(13). Persoon, C. H. Syn. Fung. p. 30 (1801).

(14) Theissen, H. and Sydow, H. Die Dothideales. Ann. Mycol. xiii, p. 576 (1915).

EXPLANATION OF PLATE.

Fig. 1. T. S. clover leaf showing mature conidial stroma with conidiophores producing conidia. × 325.

Fig. 2. Surface of leaf showing early stages in stromata development with connecting hyphal strands. No conidiophores are yet developed. × 200.

Fig. 3. Stromata at a later stage. Conidiophores beginning to appear. × 200.

Fig. 4. Hymenial surface of pycnidium. × 750.

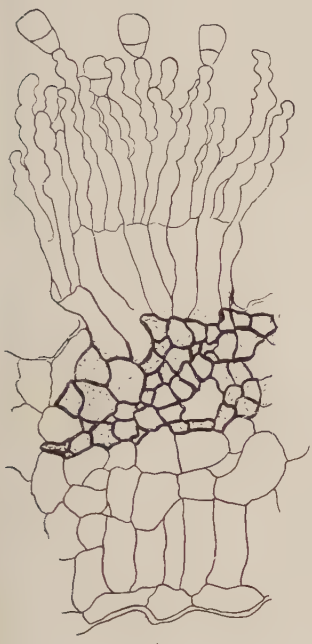
Fig. 5. Pycnidial stroma showing disintegration of pseudo-parenchymatous tissue. × 325.

Fig. 6. Asci and ascospores crushed from a perithecium. × 325.

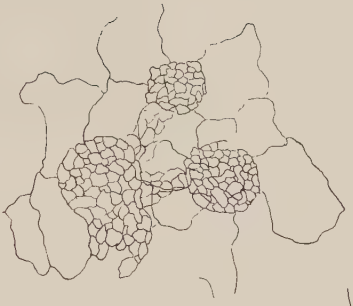
Fig. 7. Perithecial cavity showing asci associated in pairs and large fusion nucleus. *a*, paired nuclei. × 325.

Fig. 8. Later stage. L. S. stroma showing pseudo-parenchymatous tissue tending to radiate from a central point, and cells becoming less polygonal. × 325.

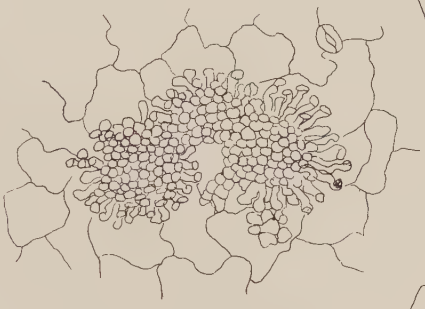
Fig. 9. *a*. Ascogenous hypha showing paired nuclei and ascus containing large fusion nucleus arising from a penultimate cell. *b*. Young ascogenous hypha.



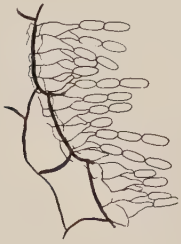
1



2

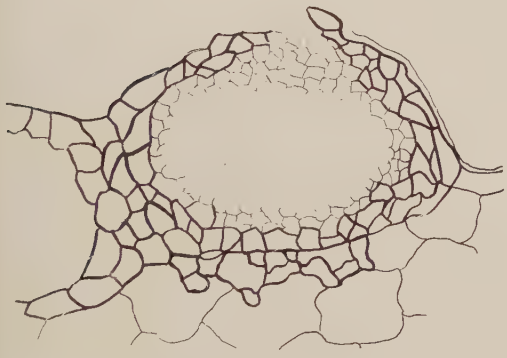


3



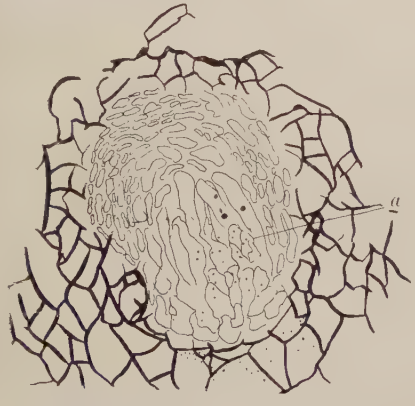
4

9

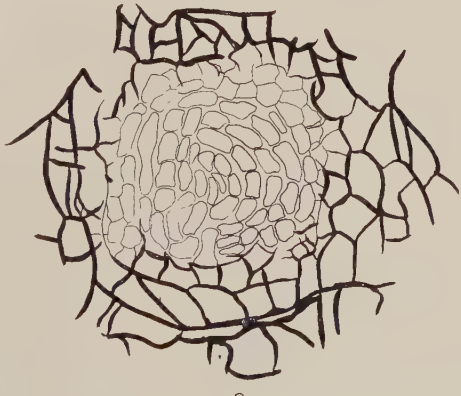


5

6



7



8

EPIDEMIC PLANT DISEASES.

By F. T. Brooks.

All of us are familiar with disease in an epidemic form as regards illness to which human beings are liable. The widespread occurrence of influenza a few years ago need only be recalled to indicate the chief characters of an epidemic. At that time, many people simultaneously became ill with influenza, which spread with great rapidity from person to person. Thus the principal features of an epidemic are the large numbers of individuals in a population affected by the disease at one and the same time, and the amazing speed with which the malady spreads from the centres where it first occurs.

Plants of economic importance, in which large numbers of individuals of the same kind are usually densely aggregated, are also liable to diseases of an epidemic nature. As in human diseases, plant maladies are frequently caused by parasitic organisms, and epidemic diseases are almost invariably of a parasitic nature; but whereas in animal diseases, these parasites are usually either bacteria or protozoa, the organisms which are the chief source of trouble to plants are of a fungoid nature. Fungoid diseases of animals are known, but most are comparatively infrequent and relatively unimportant. The reasons for this difference in character of plant and animal parasites are by no means clear, but it may be pointed out that bacteria usually thrive best in a slightly alkaline medium that is well provided with complex nitrogenous compounds, and kept more or less constantly at a lukewarm temperature. Blood is such a medium. Fungi, however, are not so exacting in their requirements; they can exist with smaller and simpler supplies of nitrogen especially if carbohydrates are abundant; they flourish over a wider range of temperature, and usually prefer a medium which is slightly acid. Needs of this kind are provided better by plant than by animal tissues. The intercellular spaces with which plant tissues abound are more readily permeated by fungal hyphae than by bacteria.

Not all diseases of plants are of an epidemic nature. Some are sporadic, *i.e.* occur only here and there and not universally over a wide area. Through neglect, however, a disease which is usually sporadic, may assume an epidemic character. Thus silver-leaf disease of fruit trees is usually sporadic in a plum plantation upon first appearance, but if neglected so that the causative fungus, *Stereum purpureum*, fructifies upon the dead branches, the disease may become so prevalent as to be epidemic. With wound parasites there must clearly be widespread opportunity

for infection (*e.g.* exposure) as well as an abundant supply of spores in order for disease to appear in epidemic form.

Epidemic diseases are essentially dependent upon two sets of factors for their development, namely, a condition of the host favourable to invasion by the parasite, and an environment of such a kind as to allow of the rapid dissemination of the spores and germination of these upon the surface of the host; these two sets of factors are intimately related to each other, for conditions detrimental to the growth of the host are often favourable to the development of the parasite. As regards the host being in a state of susceptibility to attack, it is a commonplace that individuals, whether of animal or of plant populations, vary greatly in their liability to certain diseases. It is also well known, that even the most robust individual may become so weakened as to become susceptible to diseases from which normally he is free. Plants of economic importance, most of which have been in cultivation for long ages, exist in the form of numerous varieties which shew marked differences in their susceptibility to disease. Some varieties of wheat are markedly resistant to yellow rust caused by *Puccinia glumarum*, while others are very susceptible; again in potatoes, some forms are badly attacked by the blight fungus and others are scarcely troubled by it. But often even the healthiest forms of cultivated plants may have their vitality so weakened under some conditions as to become a prey to a parasite which usually cannot thrive on it. In India for instance Einkorn wheat, which is noted for its extreme resistance to rust attacks throughout the world, becomes badly attacked by black rust (*Puccinia graminis*) during abnormally hot weather in the Ganges Valley. Climatic conditions in this case doubtless so reduce the vitality of the host plant as to render it susceptible to the parasite.

Granted, however, that the host plant is in a susceptible condition for attack, epidemic disease will not follow unless the germs of the parasite are available in abundance and unless environmental conditions favour their rapid dissemination and germination upon the tissues of the host. In fact it is not too much to say that weather conditions are usually all important in determining whether disease appears in an epidemic form or not. This accounts for differences in incidence of such plant diseases in successive years. The prevalence of one of the commonest epidemic diseases, potato blight, is chiefly determined by weather conditions. In a wet summer great damage may be done by the vigorous spread of this fungus, and so rapid is the onslaught of the parasite under suitable weather conditions that potato fields sometimes become black in a day or two. In a moderately dry summer, potato blight, though usually present

to a slight extent, is of negligible importance. Under these conditions the spores of the fungus are produced in much smaller numbers and the majority of them, even if they alight on potato leaves, are unable to germinate and cause infection on account of lack of moisture. Correlated with a heavier rainfall, potato blight is generally more severe in the west of England than in the east.

If climatic conditions are such as to prevent entirely or almost entirely for a season the occurrence of a disease which is usually epidemic, there may elapse an interval of years before the disease again assumes serious proportions. The dry summer of 1921 prevented almost entirely the appearance of potato blight, which has been uncommon in most parts during 1922 and 1923, notwithstanding weather conditions apparently favourable to it. The reason for this may be that the sources of infection were largely destroyed by the heat and drought of 1921 and that there is a necessary lag until the sources of infection are sufficiently replenished.

In temperate regions epidemic plant diseases are often checked by the oncoming of winter, during which most of these parasites are not present in an infectious condition. Mildews which are propagated in an epidemic manner during the summer by spores of a delicate nature, usually form another type of spore towards the end of the growing season, which is enclosed in an impervious case that remains sealed until the following spring. At the same time the young stems and leaves which are the parts chiefly liable to infection by such fungi either do not exist during the dormant season or have become greatly modified in structure. In the tropics, however, vegetation and weather conditions are both often practically uniform throughout the year, the temperature and rainfall varying but little in successive months. In such a climate there is no close season for fungal parasites, and epidemic diseases are greatly to be feared.

Disease may affect the subterranean parts of plants as well as the stems and leaves, and some of the most serious plant diseases and the most difficult to control are of this nature. In recent years much has been heard of wart disease of potatoes (*Synchytrium endobioticum*) in this country. This parasite invariably causes infection through the soil, in which the resting spores may retain their vitality for many years. A disease of this kind can only be epidemic when the causative parasite is generally distributed throughout the soil, for there is no means of active dissemination by wind currents. There are other ways in which root parasites may become so prevalent as to cause disease more or less of an epidemic nature. Thus if a forest or woodland be cut down and replanted with trees there are several

fungi, which, living at first on the decaying stumps as saprophytes, give rise to mycelial strands that, on passing out into the soil, invade the roots of the newly planted trees and kill them. In the early days of the rubber plantation industry in the Eastern tropics fungi of this kind were a great menace. Here also there was universality of opportunity for infection. In consequence of this danger it is now customary to remove the jungle stumps immediately after the establishment of the plantation, so that no opportunity is afforded for the development of this insidious form of disease.

The sources of infection of epidemic plant diseases are sometimes rather mysterious, and much further work is required in order to elucidate them. Many investigations have been made upon the means of over wintering of *Phytophthora infestans* and still there is obscurity about it. Recently it has been shown that the mycelium of this fungus possesses a limited power at any rate of saprophytic development in the soil and it may be that this is one of the ways in which the fungus survives under natural conditions, especially in such warm areas as the Penzance district and the Isle of Wight. It may be that the fungus is really endemic in such centres in a manner somewhat similar to the continued occurrence of cholera in certain districts in India in years when the disease is not epidemic.

The balance between host, parasite and environment in the causation of epidemic disease is usually of a delicate nature. A slight change in environmental conditions which may favour the host or alternatively injure the parasite may be quite sufficient to prevent the establishment of an epidemic. Thus *Puccinia glumarum* is commonly present in epidemic form on wheat in this country because the temperatures of the winter are usually insufficiently low to kill the uredospores of this fungus. *Puccinia graminis*, on the other hand, is a comparatively rare fungus here (except on cereals in immediate association with barberry bushes) because its uredospores cannot survive the winter temperatures which are harmless to *Puccinia glumarum*.

There is some evidence, perhaps of a not very critical nature, that the parasite itself may be more virulent at certain times than at others. There is a parallel to this in certain human diseases. For instance, during the last few years, there have been successive waves of influenza some of which were much more virulent than others. This was probably due to variations in virulence of the bacteria causing the disease, although it may be argued that this phenomenon resulted from a special degree of susceptibility on the part of mankind at the time of most serious attack. With plant parasites it is often found that, upon introduction into a new country, they spread with great rapidity

during the first few years until a climax of intensity is reached, after which their attack is less serious. Thus potato blight was introduced into Europe during the early part of the nineteenth century and rapidly spread so that in 1840 it was responsible for a complete failure of the potato crop in Ireland, thereby causing a serious famine; it is doubtful whether this fungus has ever been so virulent since. Another illustration may be taken from a disease which has been introduced into this country in recent years. About 1900 American gooseberry mildew became accidentally established in the British Isles, and immediately began to spread rapidly, so that in a few years all fruit areas where gooseberries were grown on a large scale were attacked by the disease. After some years, however, this parasite became less prevalent, and it may be that its period of maximum virulence has passed, although there has been a considerable recrudescence of the disease during 1922 and 1923.

The example of American gooseberry mildew is an illustration of the danger of the introduction of a parasite to a country where it is not native. Sometimes the climatic and other conditions of the new country are unfavourable to the parasite, but frequently it is otherwise, when there is grave risk of the establishment of disease in epidemic form. There are two destructive tree diseases in the United States which illustrate this principle. One of these is a fungus, known as *Endothia parasitica* which, native on certain species of chestnut trees in China, has in some unknown manner been introduced into the eastern parts of the United States, where it has caused immense damage to indigenous chestnut trees. The spores of this fungus germinate on slightly wounded parts of the branches and trunks of these trees, causing infection of the bark, which is rapidly killed. This fungus, at first only sporadic, has spread over large areas, notwithstanding the costly efforts that have been made to check it by felling wide belts of trees between diseased and healthy areas.

Another disease which has aroused consternation in the United States is the blister rust of five-needled pines, including the valuable Weymouth pine, *Pinus strobus*. It is known exactly how this disease was introduced into America, and the story is not uninteresting. The Weymouth pine is native to the United States, and being a valuable timber tree, has been used for forestry purposes in Central Europe. Nurseries of this tree were established in European countries where there are other closely allied pines which are attacked by the rust fungus, *Cronartium ribicola*, the disease affecting chiefly the bark of the trees. Upon the introduction of the Weymouth pine to these countries, it also was attacked by this fungus. For some extraordinary reason American foresters sent to Europe for nursery stock of

the Weymouth pine, instead of relying on their own resources. In those days there was no adequate system of plant disease inspection at the ports, and it was subsequently found that this European nursery stock introduced with it the deadly blister rust fungus which began to spread to the indigenous Weymouth pines before measures were taken to combat it. This disease is now one of the most serious that American foresters have to contend with, and its introduction shews the folly of allowing cultivated plants to be distributed throughout civilised countries without safeguards to prevent the transmission of disease. The blister rust of the Weymouth pine is unfortunately common in this country, and is the chief reason why this tree is not used more extensively for afforestation. Epidemic disease on these pines is here dependent upon the presence of an alternate host, *Ribes* spp., because the fungus cannot propagate itself directly from pine to pine. On the other hand the presence of pines (apart from an initial source of infection) is not necessary for the continuation of an epidemic on currant bushes.

Again, when a new plant is introduced into a country, a parasite often attacks it violently although the pest has only been found hitherto sporadically upon related indigenous plants. Coffee was introduced into Ceylon as a plantation crop about 1870, and an important industry sprang up in connection with it. Soon, however, it began to be attacked by a fungus disease (*Hemileia vastatrix*), which up to that time had only occurred to a slight extent upon jungle plants closely related botanically to coffee. With large numbers of plantations in close proximity to each other, the disease spread rapidly and became so uncontrollable that coffee-growing in the island became unprofitable. Heavy losses were incurred, and a few years after the commencement of the epidemic, coffee ceased to be grown on a commercial scale in that part of the tropics. That is an illustration of the danger of disease breaking out in epidemic form upon a newly introduced economic plant, the disease itself, although indigenous, being of negligible importance until the appearance of the specially susceptible plant.

Epidemic diseases of plants are disseminated in various ways. Most of the parasites produce spores which can retain their vitality for considerable periods unless exposed to extremes of temperature, insolation or desiccation. Many of these diseases, therefore, can be distributed over relatively wide areas by means of wind currents. With such a disease as potato blight this is undoubtedly the chief means by which the fungus is spread in an epidemic condition. Upon first development of the fungus in an active or sporing state in any season, the disease in its initial

stages is present only on a few plants in the crop. Spores are produced on these plants and are then distributed by wind so that other plants in the vicinity become infected. The same considerations apply to mildews and rust fungi. The power of wind, however, to disseminate fungoid diseases over immense areas, has undoubtedly been exaggerated. It used to be thought that disease could be spread in this manner from one country to another over wide tracts of sea, but this has been shown to be untrue. Delicate fungus spores which have been in the air a long time have probably been exposed to many vicissitudes of temperature, insolation, and desiccation. These changes greatly impair their vitality and by the time they reach a plant susceptible to infection, most of them are dead. It has been demonstrated for instance that bacterial germs are rapidly killed by exposure to strong light, and doubtless the same appplies to many fungus spores. Furthermore, spores being light bodies are to a great extent carried by convection currents to the upper atmosphere, where conditions are of a more extreme nature, and from which many of these germs will not fall in a living condition.

The limited power of wind currents to disseminate fungoid diseases is well illustrated by certain heteroecious rust parasites. One of these (*Puccinia Pruni-spinosae*) alternates between certain species of anemone and plum trees, in the former of which the fungus lives indefinitely, producing spores each spring. These spores infect plum leaves, but it is only the trees in the immediate vicinity of the infected anemones, especially in the direction of the prevailing wind, that first become attacked. The spores produced on the anemone seem only to be able to infect the alternate host within the range of about a mile or so, and it is not until secondary spores are formed on the plum leaves that the fungus spreads over wider areas. These secondary spores are formed within about ten days of infection, and the fungus is propagated by these during the summer in ever-widening circles.

Nowadays emphasis is laid upon the need for contact in the dissemination of many parasitic organisms. By maintaining contact, is meant bringing the parasite into the immediate vicinity of a healthy and susceptible host by means of some living or mechanical agency. This has long been recognised in human diseases, for, in many of these, individuals only become attacked by coming into close association with others already affected, notwithstanding the fact that the germs of many of these diseases must be commonly present in the air. The inability of the germs casually present in the air to cause infection is due partly to the fact that their vitality is rapidly destroyed by exposure to bright sunlight and partly to the germs being present in quantity less than the minimum requisite to cause

infection. In connection with the point last mentioned, it is a well-known axiom in medical science that the danger of infection increases with the magnitude of the dose of the disease, so to speak, to which one is exposed; there is no doubt, for instance, that even the healthiest man would succumb to tuberculosis if he inhaled an atmosphere saturated with the tubercle bacillus. With plant diseases the same principles are only just beginning to be recognised. The means by which the germs of these diseases are brought into contact with their hosts are often different from those of animal diseases, but they are none the less sure. It is now known that many infectious plant diseases are chiefly spread by insect agency, and occasionally by birds. There is a widespread group of plant diseases of great economic importance, known as mosaic diseases, which are characterised first by a mottling of the leaves with yellow spots and then by general degeneration. No organisms have yet been isolated which can be considered the cause of these diseases, but if the sap of an affected plant is inserted into a healthy one, the latter soon becomes diseased. Such diseases and others of a similar nature are known as viruses. They are of common occurrence in animals and are often supposed to be due to organisms of ultra-microscopic size. Foot and mouth disease in animals and the mosaic diseases of tobacco and potatoes are maladies of this nature. Mosaic disease of tobacco is one of the chief factors limiting the growth of the finest kinds of tobacco in those regions of the tropics, such as Sumatra, otherwise favourable for their growth. It has been shown recently that these mosaic diseases are largely spread by means of insects, especially by aphides, which, having visited diseased plants, puncture healthy ones, and thereby insert the virus. Apart from mosaic diseases, insects play an important rôle in the dissemination of plant maladies caused by known parasitic organisms, whether bacteria or fungi. The insect in sucking or biting the tissues of a diseased plant inevitably comes in contact with the germs of the parasite, some of which adhere while it passes to another plant, which may thus become infected. In fact, so intimate is the incidence of certain insect and fungus pests, that widespread opinions prevail amongst cultivators that fungi inevitably follow particular insects. One of the commonest diseases of apple trees is "canker," caused by the fungus, *Nectria galligena*, which sometimes follows in the wake of woolly aphis, one of the most serious insect pests of apple trees. This sequence is probably assisted in two ways, first by the insect carrying the spores of the fungus entangled in its woolly appendages, and secondly because the insect punctures the bark, thereby creating wounds by which the fungus can invade the branches. Again, in the rubber plan-

tations of Malaya one of the diseases of rubber trees is an affection of the bark which is brought about frequently by the combined action of an insect and a fungus. The insect is a boring beetle which usually attacks only dead wood, but which under certain circumstances invades the bark of living rubber trees, especially if this has been exposed to injury. In the dead wood inhabited by these borers the fungus *Ustulina zonata* is often found growing as a saprophyte, and as the boring insects pass from the dead wood to the living rubber trees they carry with them the fungus which, upon being thus established in the tissues of the rubber trees, spreads rapidly and acts as a destructive parasite. Such instances could be multiplied many times.

Not only do animals of a lower order play an important part in the dissemination of plant diseases, but man himself must plead guilty to this offence. Civilisation is responsible for certain evils, not the least of which is the scattering broadcast over the world of serious plant pests by the hand of man. This has only recently come to be recognised, unfortunately too late to prevent the introduction into new countries of some pests which cause great havoc. As often happens, the stable door has been locked after the horse has gone, but many countries have now established a system of plant import inspection which will prevent the introduction of new troubles of this kind. In the United States this control of plant imports is now so rigorous that certain classes of plants are entirely excluded from entry into the country. A few illustrations may be given of some of the ways in which the agency of man may be traced in the distribution of fungus pests. Less than twenty years ago, wart disease of potatoes was known to exist only at a few places in England and Scotland, but since then it has spread to some extent practically all over these countries and has reached America also. Some of the districts infected with this disease are renowned for the quality of their "seed" potatoes, which, in consequence, get distributed far and wide. During the war, when every effort had to be made to grow the maximum quantity of potatoes, "seed" tubers were distributed from one part of the country to another on a much bigger scale than ever before. There is no doubt that in this process wart disease was distributed at the same time. No one of course could think of using "seed" tubers bearing the warty outgrowths characteristic of this disease, but tubers apparently healthy, may bear the resting spores of this fungus in particles of soil adhering to the tubers. Certain varieties of potatoes are entirely immune to this disease. Notwithstanding their own immunity, these varieties may be the means of carrying the disease to healthy gardens, for the

spores adhering to the surface become detached into the soil and are there ready to infect any susceptible variety that may be planted in following years. During the war it was impossible to ensure that no seed potatoes were taken from infected land, and hence the disease is now present to a certain extent at any rate in practically every county in England, whereas only a few counties were affected in the year before the war. There is no doubt that the fungus was introduced into the United States some years ago by the importation of seed potatoes. In another class of disease, such as a surface mildew, of which American gooseberry mildew is a convenient example, two types of spores are produced; one of these propagates the fungus rapidly during active growth in the summer; the other is enclosed in an impervious covering and serves to tide the fungus over adverse winter conditions, these spores germinating in the spring upon release from their protective coats. Both types of spores may be distributed by mechanical means in the following manner. The winter "spores"—as one type may be called—adhere to the twigs of the gooseberry bushes and may be inadvertently carried in this way from nurseries to commercial and private gardens. It is customary before gooseberry bushes are despatched from a nursery where mildew has been present, to cut back the extremities of the shoots, but this precaution does not entirely ensure against the resting "spores" being distributed with the nursery stock, because these may fall on to the bud scales or into cracks in the bark. The summer spores, which are scattered to some extent by wind currents, may be distributed over wider areas by other agencies. The baskets in which the gooseberries are sent to market have been one such means: it is impossible to exclude all diseased fruit in packing, the spores from which may be carried with the basket to a new destination, for the empty baskets are not always returned to the place from which they were sent. Spores which adhere to these baskets get blown on to healthy bushes and infect them. During the period when American gooseberry mildew was spreading rapidly in this country it was quite common to find that the first bushes in a plantation to become diseased were those in the neighbourhood of the packing sheds, *i.e.* in the immediate vicinity of the place where the baskets returned from the market were stored. Spores of such diseases may also be carried directly by human agency. Persons walking amongst diseased plants may carry away with them spores adhering to their clothes. Upon going to another garden, these spores may fall from their clothes and infect healthy plants.

The economic losses caused by fungal diseases in general and by those of an epidemic nature in particular are collectively

enormous. Probably many millions of pounds are lost every year by the attacks of parasitic fungi upon food plants. It is by no means unknown for a disease of epidemic character to wipe out the cultivation of a certain product in an entire country, but the toll levied is usually of a more insidious kind. For instance, even in the best wheat-growing countries, the losses of crop due to attacks of rust fungi are computed to be rarely less than 10 per cent., and are often more, while in certain parts of Canada, Australia and Africa, the loss of crop from this cause may be nearly complete. With wound parasites, the losses may be equally serious if the diseases caused by them are neglected.

NOTE.

FLORA OF A BLACKBIRD'S NEST IN AUGUST.

A very young visitor brought in to me the other day a blackbird's nest of this year's building and opportunity was taken to examine the material. Quite a number of Pyrenomycetes were found to be in fruit. Other families were conspicuous by their absence. The short list is perhaps of some interest as showing what species were in fruiting condition on August 15th, 1923, after a very dry summer. It should be stated to the credit of the blackbird as a collector that several of the species had not been noted in the locality before.

Mycosphaerella maculiformis (Pers.) Schroet. on leaves.

Leptosphaeria microscopica Karst. on grass leaf.

Leptosphaeria Doliolum (Pers.) Ces. and de Not.

Leptosphaeria rubicunda Rehm on herbaceous stem. Spores 27–30 × 2·5–3 μ. Grove (*Journ. of Bot.* 1912, p. 49) says 20 × 2·5 μ, on Conium. I have a specimen on an umbelliferous stem from Gloucestershire with spores—25–40 × 3·5–4·5 μ, second cell from above swollen. Winter says 45 × 2·5–3 μ. Probably all one species.

Leptosphaeria derasa (B. and Br.) Auersw. on *Senecio Jacobaea*.

Pleospora herbarum (Pers.) Rabh.

Pleospora infectoria Fuck. on grass stem.

Ophiobolus tenellus (Auersw.) Sacc. on stem of *Galium* sp.

Gnomonia inclinata (Desmaz.) Auersw. on horse-chestnut leaf.

Gnomonia cerastis (Riess) Ces. and de Not. on *Acer campestre* peduncle.

Rhytisma acerinum (Pers.) Fr

Vermicularia Dematium (Pers.) Fr. on woody stem.
Vermicularia trichella Fr. on ivy leaf.
Periconia pycnospora Fres. on stem.

H. C. Hawley.

September 1923.

REVIEW.

A Handbook of the Larger British Fungi, by John Ramsbottom, O.B.E., M.A., F.L.S. Pp. 222, 141 figures in the text. Printed by order of the Trustees of the British Museum, 1923. *7s. 6d.*

The present book originated in the necessity for a new edition of the *Guide to Sowerby's Models of British Fungi*, and is therefore necessarily somewhat limited in its form and arrangement. Mr Ramsbottom has however succeeded most happily in so revising the matter and correlating it with more recent work that the book forms now an excellent introduction to the study of the larger British fungi. Beginners to whom the fuller systematic works are bewildering will much appreciate the clear, brief presentation of all the British genera of Basidiomycetes and the larger Ascomycetes.

In the fourteen pages of introductory matter Mr Ramsbottom has contrived to pack an amazing amount of interesting and up-to-date information on such subjects as "Fairy Rings," Mycorrhiza, Luminosity of fungi, Chemical characters, such as colouring matters and poisonous principles, Ecology of fungi, etc. Further there is a brief introduction to each order embodying the results of recent work on anatomy, cytology and development.

Genera which are not represented by models in the Sowerby collection are printed in smaller type. References are also given to the collection of coloured drawings of fungi by W. G. Smith exhibited in the Botanical Department of the British Museum. Where the names given to species, in accordance with the book's function as a *Guide*, do not coincide with those accepted in modern usage, Mr Ramsbottom has added the newer name in brackets and italicised, so that there should be no difficulty in correlation with other works.

The selection of species for mention has been based on their edible or poisonous qualities, and this fact, together with the general information given as to the food value of fungi and the

poisons contained in certain species, should render the book popular and useful to those interested in this side of the subject.

The genera are illustrated by W. G. Smith's line drawings as in the original *Guide.*

For the specific names of Agarics Mr Ramsbottom has followed the system of citation of authors adopted by W. G. Smith in his *Synopsis of British Basidiomycetes.* Although strictly in accordance with the International Rules of Nomenclature as they stand at present, the method in this particular case is open to serious objections on the ground of convenience, with no particular compensating argument in its favour. It seems very desirable that the next International Congress should pass the recommendation brought forward by the late Professor G. F. Atkinson in 1910, that the subdivisions of Agaricus used by Fries in his *Systema Mycologicum* should be treated as having been employed as genera at the time of the publication of that work.

A few slips occur which should be corrected in any future edition. On p. 10 under the section on Mycorrhiza the reference to Corticium should obviously apply to *Rhizoctonia solani* and not to *R. violacea* as stated. In the key to the genera of Agaricaceae on p. 20 beginners may be misled by the placing of Anellaria (spelt Annelaria) on a level with Amanita, as if it possessed a volva. Such slips, however, are very few, and typographical errors are so rare that no others have been detected.

E. M. W.

OBITUARY NOTICE.

HENRY CUSACK WINGFIELD HAWLEY (1876-1923).

By J. Ramsbottom.

Sir Henry Cusack Wingfield Hawley, Bt., died at Bournemouth on November 18th, 1923, and was buried at Leybourne Grange, West Malling, Kent. He was born on Dec. 23rd, 1876, and after being at Parkside, Worcester Park, went to Eton and thence to Magdalen College, Oxford, where he took honours in Moderations and History. After leaving Oxford he read for the Bar and was a member of the Society of the Inner Temple but never practised. He succeeded to the baronetcy on the death of his father in 1909 and was the 6th baronet.

In Sept. 1914 he obtained a commission in the 8th Battalion Royal West Kent Regiment, proceeded as Captain to France and served in the firing-line till the Armistice; after which he commanded a Labour Company till his demobilisation in May 1919.

Sir Henry was a keen naturalist and was interested in all kinds of outdoor life, but—though his great-uncle Sir Joseph Henry Hawley was the "lucky baronet" so famous on the turf, having won the Derby no less than three times—horse-racing had no attraction for him. He was more proud of his relationship to Sir Joseph Banks, whose aunt had married Dr James Hawley, F.R.S., the father of the first baronet. He was a thoroughly capable botanist and horticulturist and was well versed in arboriculture. His chief interest was, however, mycology, and in this he became thoroughly efficient and gained considerable reputation as an authority on Pyrenomycetes. He was a most careful worker and had the invariable practice of jotting down all his observations on paper. He seems to have begun to specialise on Fungi owing to meeting with Charles Crossland. A foray of the Lincolnshire Naturalists' Union took place at Lincoln on Oct. 3rd, 1905, and Crossland acted as leader: "Mr Hawley helped Mr Crossland in a most enthusiastic manner, and will accept the position of recorder for the Union." In a letter on Oct. 7th Crossland writes: "Many thanks for your kind sentiments in regard to the Lincoln Foray. It was one of the pleasantest surprises I have experienced for some time to meet with someone in your county who takes so great an interest in this much neglected, but very important, branch of botany. The interest in the study will grow upon you as it has done upon me." After discussing certain of the species they had found, he goes on to say: "We have no need to feel uneasy at not being able to determine all the agarics we meet with, either at sight, or from books at our disposal. I have been with Dr Cooke, W. G. Smith, Massee and others who, though the first two have had 50 years' experience, have been occasionally at a loss to say definitely what certain species were." Crossland advised him as to his early finds and suggested his entering into correspondence with specialists in various groups, and judging from the few letters he retained, the specimens he sent were almost invariably of more than passing interest. Owing to Crossland's special knowledge of the group, special attention was naturally paid to Discomycetes, and Boudier gave his opinion on many of the difficult species. Pyrenomycetes began to be studied about 1908, for Crossland writes in June of that year "Re the *Sphaeria*. We shall get rather more familiar with the 'enemy' in a bit and rather welcome their appearance." The following year he wrote: "Massee told me you had been at Kent. Also that it was possible you might spend a bit more time there later on and work at the Pyrenos—or some group of these. I wish you would: there is a very good opening in that direction. Very few, if any living Englishman besides Cooke, Plowright and Massee know any-

thing about them. Massee will have his MS. for a Pyreno vol. he promised some years ago that the publishers haven't tackled yet." Hawley, though still taking a great interest in fungi in general, became more and more interested in Pyrenomycetes, and after the war settled down in earnest to the preparation of the Monograph which he had considered the possibility of ten years previously. Unfortunately, the manuscript as he left it is not sufficiently complete for publication. This is particularly to be regretted, not only on account of the great need for such a volume but also because in the course of the work only the short series of "Notes on Some British Pyrenomycetes" (*Trans. Brit. Myc. Soc.* VIII (1923), p. 226) and an abstract of a general paper on "The Pyrenomycetes and some problems they suggest" (*Naturalist*, 1912) were published. With the addition of the report of the fungi of Clare Island with Mr Carleton Rea (*Proc. Roy. Acad.* XXXI (1912)) and one or two notes on other mycological matters these are the only papers which stand to the name of one of our most careful workers.

In manner Hawley was exceedingly self-effacing. Hale and hearty in appearance he at first struck one as being exceedingly shy until one realised that there was a complete absence of nervousness. After the war this reserve seemed not quite so marked, but this was probably merely that one got to know him better. In the hell of the battle of the Somme this imperturbability impressed his fellow-officers and men who were, as he himself, undergoing their blooding of heavy bombardment. It is indeed strange that the same mannerism which when first encountered at a mycological meeting rather inhibited understanding should have enabled him to appear unconcerned and cheerful under conditions man had never faced before, then attracted and impressed his comrades in such a way that on his death they bore tribute to this very character.

The news of Sir Henry's death came as a great surprise to most of us. Little did we know that the letter accompanying the short account of the fungi found on a blackbird's nest* which he sent to the Windsor Foray, in which he mentioned that he had been "a little unwell" was, as he himself realised, his farewell.

Lady Hawley has generously presented his specimens, manuscripts and drawings to the National Herbarium.

* See p. 239.

LIST OF MEMBERS.

Honorary Members.

Bresadola, M. l'Abbé, Via Cr. Madruzzo 11, Trento, Italia. (1921.)

Patouillard, M. N., Docteur en pharmacie, 105, Avenue du Roule, Neuilly-sur-Seine (Seine), France. (1920.)

Rea, Mr Carleton, B.C.L., M.A., 6, Barbourne Terrace, Worcester, (1896). (1918.)

Thaxter, Professor R., 7, Scott St., Cambridge, Mass., U.S.A. (1920.)

Ordinary Members.

1. Aberdeen, The University Library. (1916.)
2. Adams, Rev. J. H., Fernleigh, Windmill Road, Minchinhampton, Glos. (1919.)
3. Adcock, Mr Archie, Upton Road, Norwich. (1921.)
4. Alcock, Mrs N. L., Ministry of Agriculture, Pathological Laboratory, Milton Road, Harpenden, Herts. (1919.)
5. Alexander, Rev. Philip J., C.J., St George's College, Weybridge (1921.)
6. Allen, Miss I. M., Guilden Morden, Royston, Herts. (1922.)
7. Arundel, Mr H., c/o Nobel's Explosives Co., Ltd., Ardeer Factory, Stevenston, Ayrshire. (1924.)
8. Bagchee, Mr K., Botanical Department, Imperial College of Science, South Kensington, London, S.W. 7. (1920.)
9. Baker, Mr Thomas, 191, Lees Road, Oldham. (1923.)
10. Barnes, Mr B., B.Sc., Birkbeck College, Breams Buildings, Chancery Lane, London, E.C. 4. (1922.)
11. Barnett, Miss E. C., B.Sc., Botany Department, Marischal College, Aberdeen. (1921.)
12. Barr, Rev. Robert, T.D., M.A., The Manse, Neilston, Renfrewshire. (1918.)
13. Barrington, Dr F. J. F., University College Hospital, Medical School, University Street, London, W.C. 1. (1901.)
14. Bartlett, Mr A. W., M.A., B.Sc., Dept. of Botany, Armstrong College, Newcastle-on-Tyne. (1920.)
15. Batten, Miss L. S., Ph.D., Botanical Department, Imperial College of Science, South Kensington, London, S.W. 7. (1921.)
16. Beaumont, Mr A., Seale-Hayne Agricultural College, Newton Abbot, Devon. (1924.)
17. Bedell, Mr B. F., Greenaway Cottage, Limpsfield, Surrey. (1922.)

18. Bewley, Mr W. F., D.Sc., Experimental and Research Station, Cheshunt, Herts. (1922.)
19. Biffen, Professor R. H., M.A., F.R.S., 136, Huntingdon Road, Cambridge. (1899.)
20. Birmingham Natural History and Philosophical Society, c/o Mr J. W. Moore, 151, Middleton Hall Road, King's Norton, Birmingham. (1920.)
21. Bisby, Mr Guy R., Ph.D., Manitoba Agricultural College, Winnipeg, Canada. (1921.)
22. Blackman, Professor V. H., M.A., F.R.S., Imperial College of Science, South Kensington, London, S.W. 7. (1900.)
23. Blackwell, Miss Elsie M., M.Sc., Botanical Department, Royal Holloway College, Englefield Green, Surrey. (1917.)
24. Blagden, Mr Charles Otto, 57, Earl's Court Square, London, S.W. 5. (1910.)
25. Bloom, Mr James Harvey, M.A., 31, Veronica Road, Upper Tooting, London, S.W. 17. (1915.)
26. Bolas, Mr B. D., 60, Grove Park Terrace, Chiswick, London, W. 4. (1924.)
27. Borthwick, Mr A. W., D.Sc., Forestry Commission, 22, Grosvenor Gardens, London, S.W. 1. (1911.)
28. Bose, Professor S. R., M.A. (Calc.), F.L.S., Carmichael Medical College, 1, Belgachia Road, Calcutta, India. (1921.)
29. Boston, The Mycological Club, c/o Miss Jennie F. Conant, 26, Prospect Street, Melrose, Mass., U.S.A. (1906.)
30. Bourdot, M. l'Abbé H., St.-Priest-en-Murat, par Montmarault, Allier, France. (1921.)
31. Boyd, Mr D. A., St Clair, Caledonia Road, Saltcoats, N.B. (1906.)
32. Bracher, Miss R., M.Sc., Bishop Wordsworth's School, Salisbury. (1922.)
33. Braid, Major K. W., B.A., B.Sc., B.Sc. (Agr.), A.I.C., Herbarium, Royal Botanic Gardens, Kew. (1922.)
34. Brazier, Mr E., Brook Road, Oldwinsford, Stourbridge. (1921.)
35. Breeze, Miss B. M., B.Sc., School of Agriculture, Cambridge. (1922.)
36. Brett, Miss M., M.Sc., Northern Polytechnic, Holloway Road, London, N. 7. (1921.)
37. Brierley, Mr W. B., D.Sc., F.R.A.I., F.L.S., Institute of Plant Pathology, Rothamsted Experimental Station, Harpenden, Herts. (1919.)
38. British Museum, The Trustees of, Cromwell Road, South Kensington, London, S.W. 7. (1914.)
39. Briton-Jones, Mr H. R., B.Sc., D.I.C., A.R.C.Sc., Research Station, Long Ashton, Bristol. (1923.)
40. Brooks, Mr F. T., M.A., F.L.S., The Botany School, Cambridge. (1907.)

41. Brooks, Mr R. St John, M.D., M.A., D.P.H., etc., Lister Institute, Chelsea Gardens, London, S.W. 1. (1921.)
42. Brown, Mr W., M.A., D.Sc., Imperial College of Science, South Kensington, London, S.W. 7. (1922.)
43. Brown University, Library, East Side Station, Providence, R.I., U.S.A. (1920.)
44. Bruxelles, Jardin Botanique de l'État, c/o M. P. van Aerdschot. (1911.)
45. Bryce, Mr G., M.A., B.Sc., Director, Department of Agriculture, Rabaul, New Guinea. (1915.)
46. Buckley, Mr W. D., 8, Victoria Street, Slough. (1916.)
47. Buddin, Mr Walter, M.A., Laboratory of Plant Pathology, University College, 7, Redlands Road, Reading. (1921.)
48. Buller, Professor A. H. R., D.Sc., Ph.D., F.R.S.C., University of Manitoba, Winnipeg, Canada. (1911.)
49. Bunting, Mr R. H., F.L.S., Agricultural Department, Aburi, Gold Coast Colony, W. Africa. (1921.)
50. Bunyard, Capt. G. N., F.L.S., 25, Bower Mount Road, Maidstone, Kent. (1920.)
51. Burr, Mr S., The Agriculture Department, The University, Leeds. (1924.)
52. Butcher, Mr R. W., Experimental Research Station, Turner's Hill, Cheshunt, Herts. (1921.)
53. Butler, Mr E. J., C.I.E., D.Sc., M.B., F.L.S., Imperial Bureau of Mycology, 17, Kew Green, Kew, Surrey. (1920.)
54. Cadman, Miss E. J., Botanical Department, Imperial College of Science, South Kensington, London, S.W. 7. (1921.)
55. Calcutta University, The Registrar. (1923.)
56. Cambridge, The Botany School. (1920.)
57. Cape Town, Union of South Africa. The Mycologist (91410), Department of Agriculture. (1922.)
58. Carr, Professor J. W., M.A., University College, Nottingham. (1896.)
59. Cartwright, Mr K. St G., B.A., c/o Dr Granger, Little Milton, Wallingford, Oxon. (1913.)
60. Castellani, Professor Aldo, C.M.G., M.D., 33, Harley Street, London, W. 1. (1922.)
61. Cayley, Miss Dorothy M., John Innes Horticultural Institute, Mostyn Road, Merton, Surrey. (1913.)
62. Charles, Mr J. H. V., 14, Fullarton Place, Stevenston, Ayrshire. (1922.)
63. Chaudhuri, Mr H., M.Sc., Ph.D., Botanical Department, University of the Panjab, Lahore, India. (1920.)
64. Cheel, Mr Edwin, Botanic Gardens, Sydney, New South Wales, Australia. (1919.)

65. Cheesman, Mr W. Norwood, J.P., F.L.S., The Crescent, Selby, Yorks. (1896.)
66. Chipp, Major T. F., M.C., B.Sc., Ph.D., F.L.S., Assistant Director, Royal Botanic Gardens, Kew, Surrey. (1919.)
67. Clarke, Miss H., M.Sc., 45, Beaconsfield Road, Seaforth, Liverpool. (1917.)
68. Clarke, Mr J. Jackson, 25, Norfolk Road, London, N.W. 8. (1920.)
69. Cleland, Mr J. Burton, M.D., Professor of Pathology, University of Adelaide, South Australia. (1918.)
70. Coimbatore, The Librarian, College of Agricultural Research, Lawley Road P.O., Coimbatore, Madras. (1918.)
71. Collett, Mr R. Leslie, M.A., Lister Institute, Chelsea Gardens, London, S.W. 1. (1921.)
72. Collins, Miss Florence, The School of Gardening, Clapham, nr. Worthing, Sussex. (1920.)
73. Cook, Mr W. R. B., Priory Lodge, Newlands Park, Sydenham, London, S.E. 26. (1924.)
74. Cooper, Miss Charlotte A., California Lane, Bushey Heath, Herts. (1911.)
75. Copenhagen, Universitets-Bibliothek, c/o P. Haase and Søn, Løvstraede 8, København K.
76. Cornell University, The Library, New York State College of Agriculture, Ithaca, N.Y., U.S.A. (1920.)
77. Corner, Mr E. J. H., Sidney Sussex College, Cambridge. (1924.)
78. Corner, Mr E. M., M.A., F.R.C.S., B.Sc., Woodlands Park, Great Missenden, Bucks. (1920.)
79. Cotton, Mr Arthur D., F.L.S., Keeper, Herbarium, Royal Botanic Gardens, Kew, Surrey. (1902.)
80. Crow, Mr W. B., M.Sc., F.L.S., Botanical Department, University College, Cardiff. (1921.)
81. Cunningham, Mr G. H., Biological Laboratory, 71, Fairlie Terrace, Kilburn, Wellington, New Zealand. (1922.)
82. Curtis, Miss Kathleen M., M.A., D.Sc., D.I.C., F.L.S., Mycologist, Biological Department, Cawthron Institute of Scientific Research, Nelson, New Zealand. (1917.)
83. Cutting, Mr E. M., M.A., F.L.S., Botanical Department, University College, Gower Street, London, W.C. 1. (1920.)
84. Darbishire, Professor O. V., B.A., Ph.D., F.L.S., The University, Bristol. (1913.)
85. Das, Mr Kedarnath, C.I.E., M.D., Principal, Carmichael Medical College, 1, Belgachia Road, Calcutta, India. (1922.)
86. Dastur, Mr J. F., M.Sc. (Bomb.), Imperial Agricultural Research Institute, Pusa, Bihar and Orissa, India. (1920.)
87. Davies, Mr D. W., B.Sc., Advisor in Mycology, Agricultural Buildings, University College of Wales, Aberystwyth. (1923.)

88. Davis, Mr J. Jefferson, B.S., M.D., University of Wisconsin, Madison, Wis., U.S.A. (1921.)
89. Day, Mr E. Metcalfe, Rowan Cottage, Minchinhampton, Glos. (1921.)
90. Dickinson, Mr S., 3, The Warren, Lillington, Leamington Spa. (1921.)
91. Dickson, Professor B. T., B.A., Ph.D., Macdonald College, St Anne de Bellevue, Quebec, Canada. (1923.)
92. Dowson, Mr W. J., M.A., F.L.S., Royal Horticultural Soc. Gardens, Wisley, Ripley, Surrey. (1920.)
93. Duncan, Mr John B., 6, Summerhill Terrace, Berwick-on-Tweed. (1923.)
94. Ealand, Mr C. A., 32, Hamlet Gardens, Ravenscourt Park, London, W. 6. (1921.)
95. Edwards, Mr W. H., Curator, The Museum, Birmingham. (1896.)
96. Elliot, Rev. E. A., The Moat, Yoxall, Burton-on-Trent. (1923.)
97. Elliott, Mrs J. S. Bayliss, D.Sc (B'ham), B.Sc. (Lond.), Arden Grange, Tanworth-in-Arden, Warwickshire. (1911.)
98. Elliott, Mr W. T., D.D.S., L.D.S., F.Z.S., F.L.S., Arden Grange, Tanworth-in-Arden, Warwickshire. (1913.)
99. Ellis, Mr David, D.Sc., Ph.D., F.R.S.E., Royal Technical College, Glasgow. (1923.)
100. Else, Mr W. J., 6 A, Britannia Square, Worcester. (1921.)
101. Engledow, Mr F. L., School of Agriculture, Cambridge. (1922.)
102. Essex Field Club, c/o Mr Percy Thompson, F.L.S., Essex Museum of Natural History, Romford Road, Stratford, London, E. 15. (1919.)
103. Eyre, Miss J. C., Ipplepen, Newton Abbot, Devon. (1915.)
104. Fenton, Mr E. W., M.A., B.Sc., F.L.S., Botanical Department, Seale Hayne Agricultural College, Newton Abbot, Devon. (1920.)
105. Finlayson, Mr Raymond A., F.L.S., 9, Addison Road, Bedford Park, London, W. 4. (1910.)
106. Fry, Miss E. J., "Hazelhurst," Pear Tree Avenue, Bitterne, Southampton. (1923.)
107. Fry, Miss P., B.Sc., A.R.C.S., Botanical Laboratories, The University, Liverpool. (1922.)
108. Gadd, Mr C. H. B.Sc., Royal Botanic Gardens, Peradeniya, Ceylon. (1921.)
109. Gandy, Mr Wallace, 78, Egmont Road, Surrey. (1923.)
110. Gardner, Capt. Frederic, c/o Lloyd's Bank, Jersey, C.I. (1898.)
111. Garside, Mr S., M.Sc., F.L.S., Botanical Department, Bedford College, Regent's Park, London, N.W. 1. (1922.)
112. Gates, Professor R. R., B.Sc., Ph.D., F.L.S., King's College, Strand, London, W.C. 2. (1921.)

113. Gilbert, Dr E. M., Botanical Department, University of Wisconsin, Madison, Wis., U.S.A. (1922.)
114. Gilchrist, Miss Grace G., B.Sc., Botanical Department, The University, Bristol. (1921.)
115. Goaman, Mr J. F., Hamble, St James' Road, Hereford. (1922.)
116. Gossling, Mrs W. L., 20, Carlton Hill, London, N.W. 8. (1922.)
117. Gough, Mr G. C., B.Sc., A.R.C.S., Ministry of Agriculture, Birmingham. (1923.)
118. Gould, Mr F. G., Elmhurst, Church Hill, Loughton, Essex. (1918.)
119. Gould, Mr N. G., Royal Horticultural Soc. Gardens, Wisley, Ripley, Surrey. (1922.)
120. Green, Col. C. Theodore, A.M.S., M.R.C.S. (Eng.), L.R.C.P. (Lond.), F.L.S., 31, Shrewsbury Road, Birkenhead. (1901.)
121. Green, Mr E. Ernest, F.Z.S., F.E.S., Way's End, Camberley, Surrey. (1917.)
122. Grinling, Mr C. H., B.A., 71, Rectory Place, Woolwich, S.E. 18. (1913.)
123. Gwynne-Vaughan, Professor Dame Helen, D.Sc., LL.D., F.L.S., 93, Bedford Court Mansions, London, W.C. 1. (1906.)
124. Haas, Mr P., D.Sc., Ph.D., F.C.S., University College, Gower Street, London, W.C. 1. (1921.)
125. Hadden, Mr Norman G., Underway, West Porlock, Somerset. (1911.)
126. Hansford, Mr C. G., B.A., Microbiologist, Department of Agriculture, Jamaica. (1921.)
127. Harvard University Library, Cambridge, Mass., U.S.A. (1923.)
128. Harvey, Mrs Cecily D., Barwick in Elmet Rectory, nr. Leeds. (1910.)
129. Hasluck, Miss I. E., Green Hill Park, New Barnet, Herts. (1922.)
130. Hastings, Mr Somerville, M.S., F.R.C.S., 43, Devonshire Street, Portland Place, London, W. 1. (1913.)
131. Hemmi, Mr Takewo, Phytopathological Institute, Dept. of Agriculture, Kyoto Imperial University, Kyoto, Japan. (1923.)
132. Hildyard, Mr F. W., 14, Lambridge, Bath. (1913.)
133. Hiley, Mr Wilfred E., M.A., F.L.S., Research Institute, School of Forestry, Oxford. (1913.)
134. Hoare, Mr A. H., 111, Blenheim Gardens, Wallington, Surrey. (1922.)
135. Hoggan, Miss I. A., 28 A, Leinster Terrace, Lancaster Gate, London, W. 2. (1923.)
136. Holden, Mr H. S., D.Sc., F.L.S., Botanical Department, University College, Nottingham. (1923.)
137. Holt, Mr W. H., 17, Ashville Road, Birkenhead. (1914.)

138. Honolulu, The Library, Experiment Station, S.P.A., Box 411, Hawaii. (1920.)
139. Horne, Mr A. S., D.Sc., F.L.S., F.G.S., Botanical Department, Imperial College of Science, South Kensington, London, S.W. 7. (1921.)
140. Howard, Mr H. J., F.R.M.S., "Lingfield," 6, College Road, Norwich. (1918.)
141. Hughes, Mr G. C., Chesterton, Bicester, Oxon. (1898.)
142. Humphrey, Mr C. J., Laboratory of Forest Pathology, Old Soils Building, University of Wisconsin, Madison, Wis., U.S.A. (1921.)
143. Hunter, Mr C., M.Sc., Botanical Department, The University, Bristol. (1921.)
144. Hurrell, Mr H. E., 25, Regent Street, Great Yarmouth. (1921.)
145. Hyde, Mr H. A., B.A., National Museum of Wales, Cardiff.
146. Illinois, The Library, University of, Urbana, Illinois, U.S.A. (1920.)
147. Iowa, Library, State University of, Iowa City, Iowa, U.S.A. (1923.)
148. Issatchenko, Professor B. L., Directeur du Jardin Botanique, Petrograd, Russia. (1923.)
149. Jaczewski, Professor Arthur de, Director, Institute of Mycology, and Phytopathology, Perspective Anglaise 29, Petrograd, Russia. (1922.)
150. John Innes Horticultural Institute, Mostyn Road, Merton, Surrey. (1924.)
151. Johnson, Mr J. W. Haigh, M.Sc., F.I.C., F.L.S., Walton, nr. Wakefield. (1919.)
152. Johnstone, Mr R. B., 134, Cambridge Drive, Glasgow. (1908.)
153. Jones, Mr G. H., B.A., Mycologist, Department of Agriculture, Ibadan, S. Nigeria. (1922.)
154. Jones, Mr Robert Fowler, Austral House, Woodhall Spa, Lincolnshire. (1918.)
155. Jørstad, Mr Ivar, Statsmykolog, Botanisk Museum, Christiania, Norway. (1923.)
156. Keef, Miss Phoebe, Mortimer Lodge, Wimbledon Park, London, S.W. 17. (1921.)
157. Keilin, Dr D., Molteno Institute of Parasitology, Cambridge. (1922.)
158. Keissler, Dr Karl, Direktor d. Botanische Abteilung, Naturhistorisches Museum, Burgring 7, Wien 1/1. (1924.)
159. Kelly, Dr Howard A., 1418, Eutaw Place, Baltimore, Md., U.S.A. (1921.)
160. Kendall, Miss O., Ministry of Agriculture, Pathological Laboratory, Milton Road, Harpenden, Herts. (1921.)
161. Kew, The Library, Royal Botanic Gardens. (1921.)

162. Kidd, Mrs Franklin, The Botany School, Cambridge. (1919.)
163. Kirby, Mr E. E., B.A., Herbarium, Royal Botanic Gardens, Kew. (1924.)
164. Knight, Mr H. H., M.A., The Lodge, All Saints' Villas, Cheltenham. (1914.)
165. Krieger, Mr L. C. C., 2114, N. Calvert Street, Baltimore, Md., U.S.A. (1921.)
166. Kulkarni, Mr G. S., M.Ag., Assistant Professor of Mycology, Agricultural College, Poona, India. (1922.)
167. Latter, Miss Joan, Botanical Department, King's College, Strand, London, W.C. 2. (1923.)
168. Leicester, The Museum, City of Leicester. (1923.)
169. Line, Mr James, M.A., School of Agriculture, Cambridge. (1921.)
170. Linnean Society, The, Burlington House, Piccadilly, London, W. 1. (1919.)
171. Lister, Miss Gulielma, F.L.S., 871, High Road, Leytonstone, Essex, and Highcliff, Lyme Regis. (1903.)
172. Lloyd, Mr C. G., The Lloyd Library and Museum, 224, West Court Street, Cincinnati, Ohio, U.S.A. (1907.)
173. Lowndes, Mr A. G., M.A., Marlborough College, Marlborough, Wilts. (1922.)
174. MacCallum, Mrs B. D., M.A., D.Sc., F.L.S., Royal Botanic Gardens, Edinburgh. (1921.)
175. Macfie, Mr John William Scott, M.A., D.Sc., 45, Rodney Street, Liverpool. (1900.)
176. Mackenzie, Miss A. D., Research Station, East Malling, Kent (1921.)
177. Mackenzie, Mr D., Afton, Busby, N.B. (1900.)
178. Main, Mr Robert, 1, Roslyn Avenue, Low Fell, Gateshead. (1918.)
179. Maire, M. René, D.Sc., Professeur à la Faculté des Sciences de l'Université, Algers, Algeria. (1907.)
180. Maitland, Mr T. D., Government Botanist, Department of Agriculture, Kampala, Uganda. (1916.)
181. Maltby, Mr G. C., 14, Northwick Road, Evesham.
182. Marmont, Mr Basil P., Windsoredge House, Inchbrook, nr. Woodchester, Gloucestershire. (1908.)
183. Marriott, Mr St John, 37, Owenite Street, Abbey Wood, London, S.E. 2. (1920.)
184. Marsh, Mr R. W., B.A., Botanical Department, The University, Manchester. (1913.)
185. Mason, Mr E. W., M.A., MSc., Imperial Bureau of Mycology, 17, Kew Green, Kew, Surrey. (1921.)
186. Mason, Mrs E. W., 10, Manor Gardens, Richmond, Surrey. (1922.)
187. Mason, Mr F. A., F.R.M.S., M.S.P.A., The Laboratory, 3, Queen's Square, Leeds. (1912.)

188. Mason, Mr F. R., Assistant Mycologist, Department of Agriculture, Kuala Lumpur, Federated Malay States. (1921.)
189. Matthews, Mr J. R., M.A., F.L.S., Royal Botanic Gardens, Edinburgh. (1921.)
190. McCutcheon, Mr William, B.A., B.Sc., Goulburn, 89, Argyle Road, Saltcoats, N.B. (1920.)
191. McDonald, Mr J., B.Sc., Mycologist, Department of Agriculture, Nairobi, Kenya Colony. (1923.)
192. McDougall, Professor W. B., University of Illinois, Urbana, Ill., U.S.A. (1921.)
193. McFarland, Mr Frank T., Ph.D., Department of Botany, University of Kentucky, Lexington, Ky., U.S.A. (1924.)
194. McIver, Mr D. G., Regent Court, Headingley, Leeds. (1924.)
195. McLean, Professor R. C., M.A., D.Sc., F.L.S., Botanic Department, University College, Cardiff. (1922.)
196. Mehta, Professor K. C., Ph.D., Department of Biology, Agra College, Agra, U.P., India. (1921.)
197. Melbourne, Mr C. C. Brittlebank, Biologist, Produce Offices, 607, Flinders Street, Melbourne, Australia. (1921.)
198. Melvill, Mr J. Cosmo, M.A., D.Sc., F.L.S., Meole Brace Hall, Shrewsbury. (1922.)
199. Menzies, Mr James, 117, Scott Street, Perth. (1917.)
200. Meulenhoff, Dr J. S., President, Dutch Mycological Society, Diezerstraat, Zwolle, Holland. (1921.)
201. Millard, Mr W. A., B.Sc., The Agriculture Department, The University, Leeds. (1924.)
202. Missouri, The Botanical Garden, St Louis, Mo., U.S.A. (1902.)
203. Miyabe, Dr Kingo, Professor of Botany, Hokkaido Imperial University, Sapporo, Japan. (1919.)
204. Montague, Mrs A., Penton, Crediton, N. Devon. (1898.)
205. Moore, Miss E. S., Ph.D., c/o the Secretary, Dept. of Agriculture, Pretoria. (1923.)
206. Moore, Mr W. C., The Botany School, Cambridge. (1922.)
207. Moss, Professor C. E., M.A., D.Sc., F.R.G.S., F.L.S., The University, P.O. Box 1176, Johannesburg, S. Africa. (1923.)
208. Murphy, Mr P. A., Sc.D., A.R.C.Sc.I., M.R.I.A., Plant Diseases Division, College of Science, Dublin. (1924.)
209. Murray, Mr G. H., F.E.S., Papuan Government Service, Port Moresby, Papua, British New Guinea. (1921.)
210. Murrell, Major Percy J., O.B.E., F.R.M.S., "Littlecroft," Orpington, Kent. (1923.)
211. Muskett, Mr A. E., Queen's University, Belfast, N. Ireland. (1923.)
212. Nagpur, The Mycologist to the Government, C.P. India. (1924.)
213. Nebraska, The Library, University of, Lincoln, Nebraska, U.S.A. (1924.)

214. Nederlandsche Mycologische Vereeniging, c/o H. A. A. van der Lek, Zoomweg 10, Wageningen, Holland. (1920.)
215. Newcastle-upon-Tyne, Literary and Philosophical Society, c/o H. Richardson, Librarian. (1902.)
216. Newman, Mr Leslie, M.A., F.I.C., F.L.S., Dip. Agr. Cantab., St Catharine's College, Cambridge. (1906.)
217. Newton, Mr W. C. F., B.Sc., John Innes Horticultural Institute, Mostyn Road, Merton, Surrey. (1922.)
218. New York Botanical Garden, Bronx Park, New York, U.S.A. (1904.)
219. Nicholson, Mr Charles, F.E.S., 35, The Avenue, Hale End, Chingford, Essex. (1916.)
220. Nicholson, Mr W. E., F.L.S., 50, St Anne's Crescent, Lewes. (1913.)
221. Noel, Miss E. F., F.L.S., 37, Moscow Court, Queen's Road, London, W. 2. (1913.)
222. North Carolina, Library, University of, Chapel Hill, North Carolina, U.S.A. (1920.)
223. Nursery and Market Garden Industries' Development Society, Ltd., Experimental and Research Station, Cheshunt, Herts. (1922.)
224. Ogilvie, Mr L., M.A., B.Sc., Department of Agriculture, Agricultural Station, Paget East, Bermuda. (1922.)
225. Ogle, Mr B. S., Hill House, Steeple Aston, Oxon. (1904.)
226. Oke, Mr Alfred William, B.A., F.G.S., F.L.S., 32, Denmark Road, Hove, Sussex. (1908.)
227. Oldham, Mr C. H., Ivy Dene, Chandler's Ford, Southampton. (1923.)
228. Ontario Agricultural College Library, Guelph, Ontario, Canada. (1920.)
229. Osborn, Professor T. G. B., M.Sc., Adelaide University, Adelaide, South Australia. (1910.)
230. Overeem, Dr C. van, Buitenzorg, Java. (1920.)
231. Page, Miss W. M., B.Sc., 19, Ledam Buildings, Bourne Estate, Holborn, London, E.C. 1 (1921)
232. Parke, Davis & Co., Librarian, Research Department, Detroit, Mich., U.S.A. (1920.)
233. Paul, The Very Rev. David, D.D., LL.D., 53, Fountainhall Road, Edinburgh. (1899.)
234. Paulson, Mr Robert, F.L.S., F.R.M.S., Glenroy, Cecil Park, Pinner, Mdlx. (1918.)
235. Peacock, Dr H. G., The Lawn, Torquay. (1896.)
236. Pearson, Mr Arthur A., F.L.S., 59, Southwark Street, London, S.E. 1. (1911.)
237. Peck, Mr A. E., Tosti, 20, Avenue Road, Scarborough. (1918.)
238. Peltereau, M. E., Notaire honoraire, Vendôme, Loir-et-Cher, France. (1909.)

239. Perthshire Society of Natural Science, c/o James Winter (Hon. Treasurer), 35, George Street, Perth. (1919.)
240. Petch, Mr T., B.A., B.Sc., Royal Botanic Gardens, Peradeniya, Ceylon. (1911.)
241. Pethybridge, Mr G. H., Ph.D., B.Sc., Ministry of Agriculture, Pathological Laboratory, Milton Road, Harpenden, Herts. (1919.)
242. Phillips, Dr H. H., 6, St John's Road, Penge, London, S.E. 20. (1923.)
243. Phillips, Mr J. F., Research Officer, Forest Research Station, Deepwalls, Knysna, South Africa. (1921.)
244. Phillips, Professor Reginald W., M.A., D.Sc., F.L.S., University College of North Wales, Bangor. (1911.)
245. Plowright, Mr Charles Tertius Maclean, B.A., M.B., King Street, King's Lynn. (1901.)
246. Potter, Rev. Professor M.C., Sc.D., M.A., F.L.S., Armstrong College, Newcastle-upon-Tyne. (1896.)
247. Potts, Mr George, Benthall House, Broseley, Salop. (1910.)
248. Preston, Mr N. C., B.Sc., Harper Adams Agricultural College, Newport, Salop.
249. Pretoria, South Africa, The Chief, Division of Botany, Department of Agriculture. (1922.)
250. Priestley, Professor J. H., D.S.O., B.Sc., F.L.S., Botanical Department, The University, Leeds. (1912.)
251. Priestley, Mrs Marion E., 2, Balmoral Terrace, Shaw Lane, Headingley, Leeds. (1919.)
252. Pusa, Imperial Mycologist, Imperial Agricultural Research Institute, Pusa, Bihar, India. (1921.)
253. Ramsbottom, Mr J., O.B.E., M.A., F.L.S., British Museum, Cromwell Road, South Kensington, London, S.W. 7. (1910.)
254. Ramsbottom, Mr J. K., c/o *Gard. Chronicle*, 5, Tavistock Street, London, W.C. 2.
255. Rayner, Mr J. F., Swaythling, Southampton. (1902.)
256. Rayner, Miss M. Cheveley, D.Sc., Bedford Collge, Regent's Park, London, N.W. 1. (1921.)
257. Rea, Mrs E. A., 6, Barbourne Terrace, Worcester. (1896.)
258. Rea, Miss M. W., M.Sc., Salem House, Sydenham, Belfast, Ireland. (1920.)
259. Rea, Miss Violet, 6, Barbourne Terrace, Worcester. (1921.)
260. Reichert, Dr Israel, Plant Pathologist, Palestine Zionist Executive Agricultural Experiment Station, Tel-Aviv, Palestine. (1924.)
261. Rhind, Mr Donald, B.Sc., Mycologist, Agricultural College, Mandalay, Burma. (1922.)
262. Rhodes, Miss Mabel, Lister Institute, Chelsea Gardens, London, S.W. 1. (1921.)

263. Rhymes, Mr Charles, High Bois, Chesham, Bucks. (1921.)
264. Rice, Captain Cyril H., B.Sc., 20, Dyson Road, Leytonstone, Essex, E. 11. (1923.)
265. Richards, Mr R. M., M.B.E., A.R.C.S., F.L.S., The Laboratory, Caledonia Estate, Province Wellesley, Straits Settlements. (1915.)
266. Ridler, Miss W. F. F., M.Sc., Botanical Department, The University, Bristol. (1921.)
267. Roberts, Mrs A. W. Rymer, The End House, Fulbrook Road, Cambridge. (1920.)
268. Robinson, Mr Wilfred, D.Sc., Department of Botany, University of Manchester. (1923.)
269. Robson, Mr R., M.Sc., F.Z.S., Writtle, Chelmsford, Essex. (1914.)
270. Rolfe, Mr F. W., Colonial and Indian Collections, Imperial Institute, London, S.W. 7. (1923.)
271. Roper, Miss Ida M., F.L.S., 4, Woodfield Road, Redland, Bristol. (1921.)
272. Rothamsted Experimental Station, Department of Mycology, Harpenden, Herts. (1923.)
273. Rushton, Mr W., A.R.C.S., D.I.C., St Thomas's Hospital, Medical School, Albert Embankment, London, S.E. 1. (1914.)
274. Rutgers College and State University of New Jersey, Library, New Brunswick, New Jersey, U.S.A. (1922.)
275. Ryan, Mr G. M., F.L.S., 35, Ladbroke Gardens, London, W. 11. (1923.)
276. St Paul, Minn., U.S.A., The Library, Department of Agriculture, University Farm. (1920.)
277. Salisbury, Mr E. J., D.Sc., F.L.S., Botanical Department, University College, Gower Street, London, W.C. 1. (1921.)
278. Salmon, Mr E. S., F.L.S., South Eastern Agricultural College, Wye, Kent. (1922.)
279. Sampson, Miss K., B.Sc., Economic Botanist, Plant Breeding Station for Wales, University College, Aberystwyth, N. Wales. (1920.)
280. Samuel, Mr Geoffrey, University of Adelaide, South Australia. (1923.)
281. Sanderson, Mr A. R., F.L.S., Research Laboratory (Rubber Growers' Association), Petaling, Federated Malay States. (1921.)
282. Schinz, Professor Dr Hans, Botanical Garden and Museum, Zurich, Switzerland. (1921.)
283. Scott, Mr W. Murray, Wakemills, Haslemere, Surrey. (1921.)
284. Scott, Mr W. W., 23, Wood Lane, Highgate, London, N 6. (1922.)

285. Searle, Mr G. Odell, B.Sc. (Agric.), Research Botanist, Linen Industry Research Association, Glenmore House, Lambeg, Lisburn, Ireland. (1920.)
286. Selborne Society, 42, Bloomsbury Square, London, W.C. 1. (1913.)
287. Sharpe, Mr C. J., Brambleside, Manor Road, Sidcup. (1905.)
288. Sharples, Mr A., A.R.C.S., D.I.C., Mycologist, Dept. of Agriculture, Kuala Lumpur, F.M.S. (1924.)
289. Shaw, Mr F. J. F., D.Sc., A.R.C.S., F.L.S., Imperial Agricultural Research Institute, Pusa, Bihar, India. (1920.)
290. Small, Mr W., M.B.E., Ph.D., M.A., B.Sc., Mycologist, Department of Agriculture, Kampala, Uganda. (1915.)
291. Smith, Mr Alexander, The Botany School, Cambridge. (1924.)
292. Smith, Miss Annie Lorrain, F.L.S., 20, Talgarth Road, West Kensington, London, W. 14. (1899.)
293. Smith, Mr F. E., B.Sc., Agricultural Department, Armstrong College, Newcastle-upon-Tyne. (1922.)
294. Smith, Miss K.E., 64, Coton Road, Nuneaton. (1913.)
295. Smith, Mr Noel J. G., 9, Braidburn Crescent, Edinburgh. (1924.)
296. Smith, Miss S. Somerford, 6, Barbourne Terrace, Worcester. (1923.)
297. Smith, Mr Thomas, 31, Granby Road, Stockport. (1918.)
298. Solberg, Miss Louise, Kobbervik Drammen, Norway. (1923.)
299. South London Botanical Institute, Tulse Hill, Herne Hill, London, S.E. 24. (1921.)
300. Southwell, Mr Herbert, A.R.C.S., 158, Lincoln Road, Peterborough. (1923.)
301. Stakman, Professor E. C., University of Minnesota, Minneapolis, Minn., U.S.A. (1922.)
302. Stansfield, Miss O. P., M.Sc., Milton Mount College, Crawley, Sussex. (1922.)
303. Stationery Office, H.M., Superintendent of Publications, Book Department, Westminster, S.W. 1. (1920.)
304. Stirrup, Mr H. H., M.Sc., Midland Agricultural College, Sutton Bonington, Loughborough. (1922.)
305. Storey, Mr H. H., B.A., Natal Herbarium, Durban, South Africa. (1922.)
306. Sutherland, Mr G. K., M.A., D.Sc., F.L.S., 110, Brackenbury Road, Moor Park, Preston. (1914.)
307. Swanton, Mr E. W., A.L.S., Brockton, Haslemere, Surrey. (1899.)
308. Swedish Academy of Sciences, Royal, Stockholm, Sweden. (1919.)
309. Sydney, Australia. The Librarian, University of. (1922.)
310. Tabor, Mr Richard John, B.Sc., F.L.S, Botanical Department, Imperial College of Science, South Kensington, London. S.W. 7. (1914.)

311. Tagg, Mr H. F., F.L.S., Royal Botanic Garden, Edinburgh. (1921.)
312. Tatum, Mr E. J., Salisbury. (1896.)
313. Taylor, Miss Beatrice Katherine, 98, Cheyne Walk, Chelsea, London, S.W. 3. (1910.)
314. Thomas, Mr H. Hamshaw, M.B.E., M.A., The Botany School, Cambridge. (1910.)
315. Toronto, University of, Librarian, Toronto, Canada. (1919.)
316. Tothill, Dr Vincent, c/o Trinidad Leasehold, Ltd., Norme l'Enfer Forest Reserve, Fyzabad, Trinidad, B.W.I. (1912.)
317. United States, Department of Agriculture. (1907.)
318. Vines, Professor S. H., M.A., D.Sc., F.R.S., F.L.S., Langstone, Exmouth, Devon. (1915.)
319. Wadham, Mr S. M., M.A., The Botany School, Cambridge. (1922.)
320. Wager, Mr H., D.Sc., F.R.S., F.L.S., 4, Bank View, Chapel Allerton, Leeds. (1896.)
321. Wakefield, Miss E. M., M.A., F.L.S., Herbarium, Royal Botanic Gardens, Kew. (1911.)
322. Wallis, Mr A., Westacre, Station Road, Kettering. (1921.)
323. Ware, Mr W. M., M.Sc., South-Eastern Agricultural College, Wye, Kent. (1924.)
324. Watson, Mr W., D.Sc., A.L.S., Taunton School, Taunton. (1923.)
325. Wayman, Mr H. W. B., 4, Vernon Place, Bloomsbury, London, W.C. 1. (1923.)
326. Welsford, Miss E. J., M.B.E., F.L.S., Mycologist, Department of Agriculture, Zanzibar. (1924.)
327. Westerdijk, Professor Johanna, Javalaan 4, Baarn, Holland. (1923.)
328. West Indies, Commissioner of Agriculture for, Imperial College of Tropical Agriculture, Trinidad, B.W.I. (1921.)
329. Weston, Mr W. A. R. Dillon, B.A., Dip. Ag., School of Agriculture, Cambridge. (1923.)
330. Whetzel, Professor H. H., M.A., New York State College of Agriculture, Cornell University, Ithaca, New York, U.S.A. (1914.)
331. Whitaker, Mr F. Owen, 89, Eccleston Square, London, S.W. 1. (1921.)
332. Whitehead, Mr T., A.R.C.S., University College of North Wales, Bangor. (1920.)
333. Williams, Professor J. Lloyd, D.Sc., F.L.S., Botanical Department, University College of North Wales, Bangor. (1921.)
334. Williamson, Mrs H. S., 3, Verulam Buildings, Gray's Inn, London, W.C. 1. (1921.)
335. Wilson, Mr A. E., Southey House, College Green, Bristol. (1920.)

336. Wilson, Mr Malcolm, D.Sc., A.R.C.S., F.L.S., Royal Botanic Garden, Edinburgh. (1921.)
337. Wiltshire, Mr S. P., M.A., Imperial Bureau of Mycology, 17, Kew Green, Kew, Surrey. (1920.)
338. Winsor, Mr A. P., A.R.C.Sc.I., Ministry of Agriculture and Fisheries, 10, Whitehall Place, London, S.W. 1. (1923.)
339. Wisconsin, The Library, University of, Madison, Wis., U.S.A. (1923.)
340. Wolf, Mr B. L., N.D.A., 55, Catharine Street, Salisbury. (1923.)
341. Wood, Mr N. J., The Cottage, Barcombe, nr. Lewes, Sussex. (1923.)
342. Woolhope, The Naturalists' Field Club, Hereford, c/o Mr C. S. Scobie, 2, Offa Street, Hereford. (1896.)
343. Worcestershire Naturalists' Field Club, c/o Mr F. T. Spackman, F.G.S., 190, Bath Road, Worcester. (1921.)
344. Wormald, Mr H., D.Sc., A.R.C.S., Research Station, East Malling, Kent. (1921.)

RULES.

Society's name and objects.

1. The Society shall be called "The British Mycological Society," and its object shall be the study of Mycology in all its branches.

Members of Society.

2. The Society shall consist of Honorary Members, Foundation Members and Ordinary Members; the number of Honorary Members shall be limited to 20, and that of Foundation Members to 100*, but the number of Ordinary Members shall be unlimited.

Honorary Members.

3. Honorary Members shall be persons of pre-eminence in Mycology, or who have rendered special service to the Society.

Foundation Members.

4. Foundation Members shall be those Members or Societies who joined the Society previous to the limit of 100 Members having been attained*.

Officers.

5. The Officers of the Society shall consist of a President, one or more Vice-Presidents, Treasurer, Secretaries, and Editor or Editors. They shall be elected annually at the Annual General Meeting of the Society.

Government of Society.

6. The government of the Society shall be vested in a Council, which shall consist of the President and other Officers for the time being, together with two or more other Members who shall be elected annually at the General Meeting, and one-half of whom shall retire each year and not be eligible for immediate re-election. The Members to retire shall be those who have been longest in office or, in case of equality, shall be determined by ballot. Ex-Presidents are *ex officio* Members of the Council.

Every Meeting of the Council shall be duly summoned by the Hon. Secretary by at least seven days' notice in writing to each Member of the Council.

* The limit of 100 Foundation Members was reached 22nd Oct. 1903.

Period of Office.

7. The Officers and Council shall hold office as from the 1st of January following their election.

Election of Members.

8. Honorary Members shall only be elected at a Meeting of the Society by a majority of the Members then present.

All Ordinary Members shall be proposed and seconded respectively by existing Members, who shall sign a certificate (see appendix) of recommendation, one at least of the proposers so certifying from personal knowledge. Every candidate for election shall sign an undertaking to abide by the Rules if elected (see appendix). They shall be elected by a majority of the Members present at any meeting of the Society or by the President and Officers of the Society.

Subscription.

9. All Ordinary Members and Societies shall pay an annual subscription of one pound, and Foundation Members five shillings, due on the 1st of January in each year. Honorary Members shall be exempt from any annual subscription.

Any Member wishing to retire from the Society shall give notice to the Hon. Secretary or Treasurer in writing before the 1st of December of the previous year.

Meetings.

10. The Society shall hold one or more Meetings annually, at a place and time determined by the Members at the preceding Annual General Meeting, or by the Council. The Annual General Meeting for the election of Officers and the transaction of other business shall coincide with the Autumn Foray.

Accounts.

11. At the Annual General Meeting of the Society in each year the Hon. Treasurer shall present duly audited accounts.

Alteration of Rules.

12. The Rules shall not be altered except by a two-thirds majority of the Members present at an Annual General Meeting. A printed copy shall be sent to every Member of the Society on election, and in the event of alteration to all Members.

APPENDIX

Form of proposal for Ordinary Membership of the British Mycological Society.

.....

of .....

being desirous of becoming an Ordinary Member of the British Mycological Society, we, the undersigned Members of the Society, certify that we consider h to be a desirable Member of the Society, and beg to recommend h for election.

Dated this day of 19

(From personal knowledge).

Certificate to be signed by the Candidate.

I hereby certify that I desire to become an Ordinary Member of the British Mycological Society and that I will abide by the Rules if elected.

INDEX

Abies amabilis, 143
— balsamea, 141
— cephalonica, 143
— Lowiana, 144
— Nordmanniana, 140, 143
— pectinata, 140, 141, 142, 143
Acer Pseudoplatanus, 183
— saccharinum, 183
Acia stenodon, 130
Acremonium araucanum, 123
Acrostalagmus cinnabarinus, 174
Aecidium columnare, 143
— elatinum, 143
— pseudo-columnare, 142, 143
Aleurodiscus amorphus, 5
Alexander, P. J., C.J., "Ecology and phenology of Surrey mycetozoa," 58
Alnus glutinosa, 140
— incana, 140
Anderson, Redvers B., B.Sc. (For.), "Observations on *Camarosporium Abietis*," 144, Pls. III, IV
Anellaria separata, 5, 34, Pl. I
Anthoxanthum odoratum, 138, 139
Apostemidium aridula, 5
Apple, 174, 175
Armillaria mellea, 161
Arnatto, 161
Arthopyrenia saxicola, 135
Aster Tripolium, 137

Barya montana, 110, 111, 113, 115, 128
Bassenthwaite, 5
Bayliss-Elliott, Jessie S., D.Sc., "The life history of *Polythrincium Trifolii* Kunze," 218, Pl. XIII
Beech, 169
Berberis Aquifolium, 136
Bertia moriformis, 130
Biatorina candida, 133
— epiblastematica, 135
Bixa Orellana, 161, 165, 166
Bracher, Rose, M.Sc., "Notes on *Rhytisma acerinum* and *Rhytisma Pseudoplatani*," 183, Pl. VII
Braid, K. W., B.A., B.Sc., "Some observations on *Fistulina hepatica* and hollow, stag-headed oaks," 210
Bristol foray, 129
Briton-Jones, H. R., B.Sc., D.I.C., A.R.C.S., "Strains of *Rhizoctonia Solani* Kühn (*Corticium vagum* Berk. & Curt.). 200
Brooks, F. T., M.A., 5
— "Epidemic plant diseases," 229
— Presidential address, "Some Present Day Aspects of Mycology," 5, 14
Brooks, R. St John, M.D., D.P.H., M.A., "A list of fungi, etc. maintained in the national collection of type cultures," 95
Buckley, W. D., "New British Discomycetes," 43
Bulgaria inquinans, 5
Buller, A. H. R., D.Sc., F.R.C.S., "Luminosity in Panus," 5

Caeoma Saxifragae, 140
— saxifragarum, 142
Caltha palustris, 136
Calyptospora Goepertiana, 143
Camarosporium Abietis, 144, 150, Pls. III, IV
Carduus heterophyllus, 135
Carex Goodenovii, 136
Casuarina equisetifolia, 153, 162, 163, 165, 166
Cephalosporium, 174, 176
Charles, J. H. V., "Spore formation in *Rhacodium cellare* Pers.," 94
Cheesman, W. N., F.L.S., "Report on the mycetozoa found during the foray at Keswick," 12
Cheilymenia dalmeniensis, 5
Chestnut, Horse, 169, 171
Chlorella vulgaris, 174
Ciliaria caudata, 45
— umbrorum, 45
Cladosporium herbarum, 101
Clavaria fumosa, 5
Clover, red, 130
Coffea arabica, 164, 166
— robusta, 153, 162, 163, 164, 165, 166
Coleosporium Melampyri, 4
— Petasitis, 142
— Senecionis, 141
Collema flaccidum, 133
Coprinus radians, 130
Cordyceps cristata, 109, 110, 111, 112, 126
— dipterigena, 111
— flavoviridis, 109, 111
— gonylepticida, 109, 111, 112
— militaris, 5
— Moelleri, 110, 126
— ophioglossoides, 5
— rhynchoticola, 109, 111, 112
— Sphingum, 126, 127

Cordyceps unilateralis, 94
Corticium Galzinii, 2
— vagum, 200, 210
Cortinarius armillatus, 5
— bolaris, 5
— largus, 5
— myrtillinus, 5
— uraceus, 5
Cryptomeria japonica, 189, 192
Cultures, type, list of, 95
Cunningham, G. H., "Development of *Gallacea Scleroderma* (Cke.) Lloyd," 193, Pls. IX, X

Dematium pullulans, 100, 174, 176
Derwentwater, 5
Diachaea cerifera, 33
Dictyolus muscigenus, 4
Discomycetes, new British, 43
Dothidella Trifolii, 227

Elaphomyces granulatus, 5
Elliott, W. T., F.L.S., F.Z.S., "Report on the mycetozoa found during the foray at Keswick," 12
Elm, *see* Ulmus
Endogone lactiflua, 4
Entoloma griseocyaneum, 4
Epilobium alpinum, 140, 141
— alsinefolium, 141
— angustifolium, 141
— montanum, 141
— obscurum, 137
— palustre, 137
— roseum, 137
— tetragonum, 137

Fistulina hepatica, 210
Flammula rubicundula, 5
— scamba, 5
Forays—Bristol, 129
— Keswick, 4
— Norwich, 1
Ford-Robertson, F. C., B.Sc., "A new species of Monochaetia," 189, Pl. VIII
Fumago vagans, 104
Fungi, A Handbook of the Larger British Fungi, by J. Ramsbottom, 240
— British Laboulbeniaceae, 78
— complete list of, Bristol foray, 130
— — Keswick foray, 6
— — Norwich foray, 2
— edible, 35
— new British Discomycetes, 43
— of a blackbird's nest, 239
Fungus present in *Lunularia cruciata*, 82
Fusarium, 170, 171, 174

Gallacea Scleroderma, 193, Pls. IX, X
— violacea, 193
Gibellula elegans, 127
Grevillea robusta, 152, 153, 165
Gymnosporangium clavariaeforme, 4
— Juniperi, 4

Hake, Winifrede L., "British Laboulbeniaceae," 78
Hastings, Somerville, M.S., F.R.C.S., "An Alpine form of *Anellaria separata*," 5, 34, Pl. I
Hawley, H. C., "Flora of a blackbird's nest in August," 239
— Obituary notice of, 241
Helicobasidium purpureum, 130
Helminthascus 110
— arachnophthorus, 111, 112, 113, 115
Hirsutella, 93, 111, 116, 128
— arachnophila, 93, 94, 127, Pl. II, fig. 10, 128
— citriformis, 93
— clavispora, 93
— entomophila, 93
— Saussurei, 94
Hoggan, Ismé A., "On *Dematium pullulans* de Bary," 100
Hordeum murinum, 137
Hormodendron chlorinum, 187
— Hordei, 187
— nigrovirens, 187
— olivaceum, 187, text-fig.
Howard, H. J., List of Myxomycetes, 4
Hygrophorus obrusseus, 5
Hypomyces aureo-nitens, 1

Inocybe praetervisa, 5
Isaria cuneispora, 116
— Saussurei, 94

Keswick foray, 4
Knight, H. H., M.A., "Keswick Lichens," 10

Laboulbeniaceae, British, 78
Lachnea appendiculata, 45
— Fleischeriana, 45
— folliculata, 45
Lamproderma brevipes, 32, 33, 34
— columbinum, 32, 33, 34
— Cruchetii, 33, 34
— iridescens, 33, 34
— sessile, 33
— Staszcii, 33
Lamprospora areolata, 45
— campylopodis, 44
— Crec'hqueraultii, 44
— dictydiola, 46
— miniata, 45

Lathyrus pratensis, 144
Latrigg, 4
Lecidea Metzleri, 133
— protrusa, 135
— testacea, 133
Leocarpus fragilis, 13
Leotia chlorocephala, 5
Leptoderma iridescens, 33
Leptogium diffractum, 133
— placodiellum, 133
Lichens, list of Bristol foray, 133
— Keswick foray, 11
Lister, Gulielma, F.L.S., "*Lamproderma columbinum* Rost. and its varieties," 32
Lunularia cruciata, 82
Lycoperdon giganteum, 1

McLean, R. C., "Remarks on the nature and definition of species," 47
Melampsora alpina, 140, 142
— artica, 140
— reticulata, 139, 140, 142
Melampsorella Caryophyllacearum, 140, 142
— Symphyti, 143
Melampsoridium Alni, 140
— betulinum, 140
Members, 244
Mesophellia Scleroderma, 193
Monochaetia, 189
— Cryptomeriae, 192, Pl. VIII
Mycetozoa, ecology and phenology of Surrey, 58
— list of, 4, 13
Mycogone perniciosa, 130
Mycorrhiza, tree, 213, Pls. XI, XII
Myriangium Duriaei, 130, 135

Neotiella Hetieri, 46
Norwich foray, 1

Oak, silky, 152
— stag-headed, 210
Ogilvie, Laurence, M.A., B.Sc., "Observations on the 'slime-fluxes' of Trees," 167, text-fig. 1
Oidium, 170
— lactis, 171, 173
Oospora, 170, 171, 172
— lactis, 171, 173
— Ludwigii, 176, 177, 178

Panus, luminosity in, 5
Parmeliella plumbea, 10
Paulson, Robert, "Tree Mycorrhiza," 213, Pls. XI, XII
Pedicularis palustris, 136
Peltigera horizontalis, 135
— rufescens, 135
Penicillium, 174, 176
Petasites japonicus, 142
— officinalis, 142
— palmatus, 142
Petch, T., B.A., B.Sc., "Studies in entomogenous fungi," 108, Pl. II
—"The genus Trichosterigma Petch," 93
Peziza aurantia, 45
Phyllachora Trifolii, 219
— umbilicata, 219
Physarum iridescens, 33
— viride, 13
Plowrightia ribesia, 103, 104, 105, 106
— Trifolii, 228
Plums, mummy, 187
Polygonum Bistorta, 137
— viviparum, 137, 143
Polyporus nummularius, 2
— radiatus, 2
— sulphureus, 129
Polythrincium Trifolii, 218, Pl. XIII
Potter, M. C., Sc.D., M.A., F.L.S., "Soil reaction on wart disease of potatoes," 5
Proceedings, 128, 188
Protococcus, 176
— viridis, 174
Puccinia Andersoni, 135
— Anthoxanthi, 138, 139
— borealis, 139
— Calthae, 136
— Cirsii, 135
— Epilobii, 137
— glumarum, 137, 138
— Hordei, 138
— mirabilissima, 136
— paludosa, 136
— Pringsheimiana, 1
— septentrionalis, 137
— simplex, 138
— Sonchi, 136
— straminis, 138
— Tripolii, 136
— Zopfii, 136
Pucciniastrum Abieti-Chamaenerii, 141
— alpinae, 141
— Epilobii, 140, 141
— pustulatum, 141, 143

Radulum mucidum, 5
Ramsbottom, J., O.B.E., M.A., F.L.S., "Hawley, H. C. W." obituary notice of, 240
Ramsbottomia, 44
— lamprosporoidea, 44
Rea, Carleton, B.C.L., M.A., &c. "Edible Fungi," 5, 35
Rhacodium cellare, 94, 95

Rhizoctonia, causing root disease in Uganda, 152
— lamellifera, 165, Pls. v, vi
— Solani, 200, 210
— violacea, 130
Rhizopogon violaceus, 193
Rhodes, Mabel, "A list of fungi, etc. maintained in the national collection of type cultures," 95
Rhytisma, 183
— acerinum, 183
— Pseudoplatani, 183
Ridler, W. F. F., M.Sc., "The fungus present in *Lunularia cruciata* (L.) Dum.," 82
Robertson, F. C. Ford, B.Sc., "*Hormodendron olivaceum*," 187, text-fig.
Rules, 259

Saccharomyces, 179
Saccobolus globulifer, 47
— violacens, 47
Salix reticulata, 139
Saxifraga aizoides, 140, 142
— hypnoides, 142
— oppositifolia, 142
Schizosaccharomyces, 174
Sclerotinia, 187
Sclerotium, 165
Scutula epiblastematica, 135
Senecio Smithii, 141, 142
Slime-fluxes, 167
— apple, 174
— brown, 168, 179
— white, 176, 180
Small, W., M.B.E., Ph.D., F.L.S., "A Rhizoctonia causing root disease in Uganda," 152, Pls. v, vi
Spathularia flavida, 5
Sphacelotheca Hydropiperis, 143, 144
— inflorescentiae, 143, 144
— Polygoni-vivipari, 144
Sphaeria Trifolii, 218
Sphaerulina intermixta, 104, 106
Sporotrichum, 176
— carnis, 174
Stansfield, Olive P., M.Sc., "The life history of *Polythrincium Trifolii* Kunze," 218, Pl. xiii
Synchytrium Taraxaci, 4

Tea, 153, 161, 165, 166
Thalictrum alpinum, 137, 139
Thea, 165
Thecaphora Lathyri, 144
Thecopsora Vacciniorum, 4, 141
Thelotrema lepadinum, 133
Thirlmere, 4
Tichothecium erraticum, 11
— gemmiferum, 11
Torrubiella, 108, 109
Torrubiella, aranicida, 108, 109, 111, 115, 116
— barda, 109, 111, text-fig. 6, 117, 123, Pl. ii, fig. 8, 128
— brunnea, 108, 111, 112, 113, 115, 116, 118, 119
— flava, 110, 111, 112, 116, 124, 127, Pl. ii, figs. 9–10, 128
— Lecanii, 108, 111, 115, 117, 124
— luteorostrata, 108, 111, 112, 113, text-fig. 2, 115, 116, 118, P. ii, figs. 2–5, 120, 128
— ochracea, 108, 110, 111, 112, 113, text-fig. 7, 115, 116, 124, Pl. ii, fig. 11, 128
— rostrata, 108, 111, 112, 113, 115, 116
— rubra, 108, 111, 112, 113, text-fig. 1, 115, 116, 117, Pl. ii, fig. 1, 128
— sericicola, 108, 111, 112, 113, 115
— sublintea, 109, 111, text-fig, 4, 116, 121, Pl. ii, fig. 7, 128
— tenuis, 109, 111, text-fig. 3, 116, 120, Pl. ii, fig. 6, 121, 128
— tomentosa, 108, 111, 112, 113, text-fig. 5, 115, 116, 120, 122
Torula, 176
— monilioides, 172
Trichia Botrytis, 13
— persimilis, 13
Trichoderma lignorum, 174
Trichoglossum hirsutum, 5
Trichosterigma, 93
— arachnophilum, 93, 127
— attenuatum, 93
— clavisporum, 93
Trifolium repens, 139, 219

Ulmus campestris, 169, 170, 171, 179, 180
— glabra, 169
— montana, 169, 171
— vegeta, 169, 171, 179
Urceolaria gypsacea, 133
Uredineae, 135
Uredo anthoxanthina, 139
Uromyces apiculosa, 139
— flectens, 139
— Lilii, 1
— Trifolii, 139
Ustilagineae, 135
Ustilago Bistortarum, 143
— glabra, 143

Vaccinium Myrtillus, 141
— uliginosum, 141
— Vitis-Idaea, 141
Verticillium cinnabarinum, 174

Wakefield, E. M., M.A., F.L.S., "Bristol Foray report," 129
— "Keswick Foray report," 4

Wakefield, E. M., M.A., F.L.S., "Norwich Foray report," 1
— "Note on *Helicobasidium purpureum* and *Rhizoctonia violacea*," 130
— Review of "A Handbook of the Larger British Fungi," by J. Ramsbottom, 240
— "Six months' mycological work in the West Indies," 5
Watson, W., D.Sc., A.L.S., "The Lichens of the Bristol Foray," 133
Whinlater, 5
Willow, 177, 180
Wilson, Malcolm, D.Sc., F.R.S.E., F.L.S., "A new species of Monochaetia," 189, Pl. VIII
— "Observations on *Camarosporium Abietis*," 144, Pls. III, IV
— "Observations on some Scottish Uredineae and Ustilagineae," 135
Wythop, 5

Yeast, 173, 175, 176, 178

CAMBRIDGE : PRINTED BY W. LEWIS AT THE UNIVERSITY PRESS